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Science and Animal Production.*

By John Hammond, M.A., D.Sc., F.R.S.†

The subject to-night, "Science and Animal Production," is a wide one, and, as I cannot cover all of it in the time, I propose to take examples here and there of the way in which science can be applied to animal production.

Many of you who are agricultural scientists will know that discoveries are made on all sorts of animals, and are then transferred to others, so that you never quite know where a new discovery is going to land you. There was a discovery made a few years ago that, by injecting the anterior-pituitary secretion (from the gland at the base of the brain) into the blood of a rabbit, you could make it produce 100 eggs instead of 10. That looks pretty useless at first sight. One does not want to encourage the production of rabbits at that rate, but the principle behind it has a very wide application.

The process of egg production in rabbits, poultry, and other species, is much the same. In a study of the rate of egg production (the number of eggs laid per month) in the different months of the year, we were struck by the fact that, in Australia and the Argentine, the curves of seasonal production were practically identical. The curious thing was that these places are on the same degree south of the Equator. Nearer the Equator, at Trinidad (in the West Indies) and on the Gold Coast of Africa, also on the same degree of latitude, we got nearly identical curves, but of different shape to the others. By plotting curves against the various environmental factors, it was found that the only thing that would really fit the curves was the hours of daylight. The seasonal egg production curves throughout the world follow the daylight curves from 55 deg. north, where there is a sharp rise in March-April, to the Equator, where they are almost flat, and then to the south of it where the curves are reversed, and one finds the peak occurring in September-October. This suggested the idea that egg production could be modified by light, and experiments were made in Denmark to test this theory. It was found that, by giving extra light after dusk during the short days of the year, the egg production rose.

* An address given at a meeting of the Western Australian Branch of the Australian Institute of Agricultural Science and of others interested in animal production, held at Pastoral House, Perth, on Thursday, 12th May, 1938. Dr. Hammond's report on his visit has already been published as the Council's Pamphlet No. 79.

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The present theory is that daylight (increasing or decreasing lengths of it) affects reproduction by stimulating, through the eyes, the pituitary gland, and so making it secrete either more or less of the active substance. This has, I believe, a wide application in Australia to the times of year at which sheep will breed. At certain times eggs will be ripened easily, but at other times only with great difficulty. This phase of production is now being investigated in Sydney by Dr. Kelley, an officer of the Council for Scientific and Industrial Research, and before long something useful to sheep breeders is likely to come out of his studies.

The foregoing is just an example to show you the twisting ways in which science works, investigations passing from one animal, and then to another, until some useful result is achieved.

Turning to a different subject, namely, the question of the diagnosis of pregnancy in animals, this is now being studied in various species. One of the latest discoveries is that the cervix (the mouth of the womb) under normal conditions, produces a thin mucus, which, when the cow is in season runs down the tail. When the animal becomes pregnant, however, this mucus becomes congealed and solidified, so that it occludes the entrance to the womb and seals off the developing embryo.

We can now diagnose pregnancy in a mare by using a long-handled paint brush and getting a swab of the mucus from the cervix. This is smeared on a glass slide to determine its consistency. In a cow you can actually put your fingers into the entrance of the cervix and take a sample from it. You cannot do that with a mare, however, because the cervix is very shallow, and it is therefore dangerous. In a cow the cervix is about 4 or 5 inches long and so no harm can be done.

These discoveries were made from fundamental studies of the changes occurring during pregnancy in animals. We were not looking for any particular thing, but made a complete study and came across these things which have served an immediate useful purpose. By using these methods one can now with certainty diagnose pregnancy at 30 days in a mare which has produced a foal that season, and in a mare which has been barren the previous season at somewhere about 60 days. Diagnosis in the cow can be made also at about 60 days.

Another line of work in which advance has been made recently is that of artificial insemination. The apparatus used is a cylinder with a rubber tube inside and a space between. The space is filled with warm water, and the apparatus is closed at one end by a rimmed glass vessel which contains some liquid paraffin. By obtaining a service into this apparatus held against the flank of the female, semen is collected in a pure state. The semen collected from an animal in this way can be preserved for some time, the length of time varying in different species. There are two main uses for this new technique. One is to inseminate a large number of females from one male. The number possible varies in the different species of animals (according to the composition of the semen) from about 2 in the boar to about 30 in the ram.

Extensive use has been made of this technique with valuable stud animals. In Russia, by this method, some of the imported rams have had up to 2,600 ewes pregnant to them in one season. The method is more applicable to ewes, cows, and mares than it is to pigs.

Another aspect of this work is the preservation of life in the sperm outside the body for a long time. This enables the export of animals to be made at a very much cheaper cost. The method used to preserve the sperm is similar to that of preserving meat and fruit. Sperms keep best at a temperature of about 40 deg. F., and when the air is excluded they are in a semi-anaerobic condition—that is, they are put into a hibernating state. This procedure has been made use of to transport sperm from one place to another. Thus we are now obtaining semen from bulls in Holland and flying it over to inseminate cows in England. Similarly, the semen of a Suffolk ram has been sent from England, and lambs have been obtained from Polish ewes.

Another use of this insemination is to enable one to cross animals which differ greatly in size. An example of this will serve to introduce the subject of growth in animals. If a large Shire horse is crossed by artificial insemination with a small Shetland pony mare, and a small Shetland pony horse with a large Shire mare you would get two different sized foals although they are of the same cross. The size of the foal depends on the size of the mother, for she controls the size of the foal to such as she can bear. This is probably due to a special nutritive substance circulating through the blood of the mother.

While the foals are suckling (at one month old) the relative size ratio of 3 to 1 in favour of the Shire mare's foal remains, but, as soon as the suckling period is completed and both foals have similar feed, that born of the pony mare begins to catch up slowly. At 4½ years old the difference in size still persists, but the ratio between the two drops from 3 to 1, to 1½ to 1. This is an example of how the size of animals may be controlled by nutrition, quite apart from genetics. The two foals are of the same cross, but the early nutrition has been different.

Let us turn now from size to conformation, for, whatever class of stock you are breeding, conformation plays a very important part. The conformation of the horse has changed in the course of evolution of the species. The early fossil horse, as compared with later fossil types, and the modern Arab (making the basis of comparison the cranium size, that is the eye to ear length in each case) had, when it was a small marshy animal, a comparatively long body and short legs. As it took to the higher ground, the length of the legs increased in relation to the body, this being an evolution for speed.

Compare this with the embryonic stages of a Welsh pony, and you will find how exactly those same changes in form are repeated. It is well known that development repeats the evolutionary history of the animal. After birth, however, another form of development begins. There is a proportional deepening and thickening of the body until adult form is produced.

If we examine the way in which our modern horses are developed, we find that the thoroughbred, which is bred for speed, is following the natural evolution of the horse and will fit on at the end of the natural evolution series. On the other hand, the development of the draught horse (illustrated by the Suffolk) which has been developed for pulling heavy loads and not for speed, fits on at the end of the post-natal stage of development which is associated with a deepening and thickening of the body.

There can be no such thing in my opinion as static body form in an animal. Changes in the body form of an animal must always take place during the life of an animal up to its matured state, but exactly what those changes will be will depend on the environment in which the animal is placed. For example, the body proportions of a man change greatly as he grows up. In the early stages the head is huge in proportion to the rest of the body, but it becomes continuously smaller and smaller as he grows up, and the legs get longer and longer. Definite changes in body proportions are continually taking place, and it is these changes which we are seeking to control. A scientist's job is first to record a thing and then to seek to control it, so as to bring it under his power as far as possible.

Now let us examine the changes in the body proportions of a Hereford bull as it grows up. At birth it is all head and legs, and the body is short and comparatively shallow. As it grows up it lengthens in body and then begins to deepen, so that in the adult animal the proportions of head and legs are small, and the most valuable parts (the loin and the rump) are large in proportion as compared with the younger animal.

Now let us see how these changes in body proportions can be controlled by nutrition. When a young, well-developed animal is put on a low plane of nutrition, it will first lose its fat and then begin to lose its flesh (muscle), but it will at the same time continue to grow its bones. The heart, lungs, brain, and bones (the vital organs) will continue to grow on a low plane of nutrition, whereas the growth of the fat and muscle (the things we value from a meat point of view) will be inhibited. Exactly the same thing happens when a calf is reared on a low plane of nutrition. It grows up to a large size with very little change in its shape. It will be high in the legs and the body will be shallow and comparatively short in proportion to its height, as compared with that of a similarly bred animal reared on a high plane of nutrition.

Under poor conditions of nutrition, therefore, you cannot pick out those which have the capacity to change their shape as they grow up. That is, your selection for meat qualities must be made in an environment suited to develop these qualities in the animal. Feeding the animal well is like putting developer on a photographic negative. By applying food to the animal you can really see what its possibilities are. When, therefore, you try to select your meat animals under conditions of poor nutrition you are unsuccessful. You merely pick out the biggest one which probably has the best way of nosing around and getting all it can, and you do not get the best beef type. You will not make any progress with breeding of meat animals unless you rear them in an environment of high nutrition.

Let us now consider what effect a low plane of nutrition has on the carcass. If the animal is high in the legs, there will be long bones with shallow meat over them, as compared with a well-fed animal which has relatively shorter bone and a greater depth of flesh. You will notice, too, that there is much more weight in the fore ends (a cheap part) of the animal reared under low nutrition than there is in the animal under high nutrition. When one cuts the carcass through at the last rib (that is where the animal grows last and suffers most), you will see quite a difference. The low plane animal will have long rib bones, and the back muscles will be long, but not very deep, making it shallow

fleshed, whereas a high plane animal will be deep fleshed, the back muscles being deep and thick. This is the type that is required in the market, whilst the other, having a high proportion of bone, and poorly developed meat, is not favoured.

Now let us turn to sheep and see how improvement in meat conformation has been brought about there. The wild sheep (Mouflon) goes through changes in its proportions as it grows up (and as in improved breeds the male reaches a higher state of physical development than the female). These changes in shape as the wild animal grows up occur to nothing like the same extent, however, as they do in our modern mutton breeds. For example the adult wild ewe will fit into a comparative scale of body shape change between the improved lamb at birth and the improved adult ewe—thus corresponding somewhat to an improved lamb at about two months of age.

As I see it, the way in which the mutton breeds have been improved is by putting them into a suitable environment and selecting for breeding purposes those animals which go through these changes in body shape most rapidly, and to the farthest extent. By this means the shortened legs in proportion to the size of the body are produced.

There is another process responsible for changes in body conformation and that is by mutation in the Mendelian sense. Such gave rise to the Ancon sheep (an animal with shortened legs). This is quite a different thing from those gradually evolved by selection in which the shortening of the legs is due to the greater development of the body of the animal in proportion to the legs. The mutant Otterschaf or Ancon is a recessive sport, and if you cross it with a long-legged sheep the progeny will all be long-legged. If, however, you cross the short-legged sheep, improved by selection, with a long-legged sheep, you get an intermediate between the two. The mutant short-legged type will come out in the second generation of cross-breeding in the ratio of one to every three long-legged born. In my opinion these mutations or sports are of no practical use for animal improvement. We have to depend on the selection and environment rather than by waiting for such freaks to occur, because mostly these freaks, when they do turn up, are not much good for commercial purposes.

Now let us see what the change in shape of the sheep means to the butcher and meat consumer. In an animal shaped like the lamb at birth, for every 100 lb. of live weight the butcher can hang up 50 lb. to sell, whereas in an animal shaped like an adult of an improved mutton breed he can hang up 67 lb., and so the butcher has much more to sell. That is why the butcher will always prefer a well shaped animal to a badly shaped animal. When the carcass is boned out, and the meat you would normally put on your plate and eat is weighed, it is found that for every 100 lb. live weight of the animal shaped like the one at birth you would only eat 31 lb., whereas with the animal shaped like the adult you would eat double (62 lb.), so much of the former consists of bone.

In that you see the reason why the breeder of sheep (and all other meat animals) pays so much attention to the form and shape of the animal. It means that if you use the right breed, it goes through these changes in shape to a considerable extent as it grows up, and it will put its food into the edible parts, whereas, if you use an animal that does not change its form very much as it grows up, it will put much of the food you give it into the unedible parts.

Now let us see why it is that the animal changes its shape and changes the composition of its body as it grows up, giving a carcass with less bone and less muscle. The explanation is this. Taking the different tissues of the body first, the rate of bone growth is high in early life; later in life the rate of bone growth begins to slacken off and gradually drops to a lower level. Muscle does not grow so fast as bone at first, but gradually begins to overtake it in the rate of growth; later in life the rate of its growth also begins to drop off. Fat is the latest tissue in developing; the young animal has comparatively little fat and the fat does not reach its maximum rate of growth until late in life.

Such statements will apply equally well to head, neck, and loin, in the same way as they do to bone, muscle, and fat, respectively, and to fat distribution in different parts of the body, internal fat, subcutaneous fat, and marbling fat (between the muscles), respectively. The effect of the plane of nutrition is either to push these growth curves for the different tissues &c., nearer together or to pull them apart. If an animal is put on a high plane of nutrition, fat growth and muscle growth is speeded up in relation to the bone growth, so that a higher proportion of fat and muscle in proportion to bone is attained in early life, as compared with the one on a low plane nutrition which has a lot of bone and very little fat.

Just as you can modify the composition of a sheep by external influences on the plane of nutrition, it can be modified by the internal influences which are probably related to the glands of internal secretion. If the internal stimuli are high the sheep will go through these changes in composition quickly, and will be of an early maturing type from the butcher's point of view.

Let us take one example of this from the changes occurring in the leg of mutton. In the Suffolk breed, in proportion to a cannon bone weight of 100 in each case, the thigh muscles are 981 at birth, 3,600 at five months, and 4,200 in adult life. The upper muscles of the leg are growing at a greater rate than the bone, and this is the reason why the shape of the leg changes as the animal grows up, the result being that, if the ratio between muscle and bone is 100 at birth, it goes up to about 500 in adult life.

If the legs of mutton of different breeds are compared at the same age (five months) and in the same way, the early maturing breeds (from the butcher's point of view), like the Southdown, change their shape very quickly as they grow up, whereas those of the late maturing breeds, such as the Lincoln, do not, although the actual weights of the two legs may be the same. The one is fit for the butcher because it has gone through the change of proportions quickly, whereas the other has not, for it has gone through these changes slowly and there is very little fat and muscle, and much bone in it. Early maturity from the butchers' point of view, means a rapid change of shape and proportions of the animal as it grows up. What does this mean in terms of actual market requirements?

In an animal which goes through these changes in proportions quickly, the upper part of the leg will be large in proportion to the lower part and you get an ideal leg, "U" shaped, with relatively short bones, and relatively thick muscles. This is the early maturing type. With the late maturing type, however, the bones are long and the muscle is

not yet developed, so that you get a "V" shaped leg, which is an undesirable one. The "U" shaped leg, because it has a large volume to surface ratio, will not dry up in transport, and will retain its moisture when put into the oven to cook. The fat will move down over the surface of the leg too, and cover it, so that when easten it is juicy and succulent. On the other hand, the "V" shaped leg will have a large surface in comparison with the volume, and it will easily dry up. There will be a lot of muscle not covered with fat, and it will be hard and dry when eaten, if it is ever able to get into the modern oven. That is the trouble nowadays—you cannot get the long-boned legs into the small gas ovens in the cities.

Let us turn back to the breeder's point of view and just see what the shape of bones will tell us from his angle. Wild and unimproved breeds such as the Soay and Shetland, have relatively long, thin, cannon bones. On the other hand the breeds improved for meat, like the Hampshire and Suffolk, have comparatively short, thick, cannon bones.

In a breed improved for wool, but not for mutton, as in the Merino, the cannon bones are relatively long and thin. In unimproved breeds, too, the femur is relatively short as compared with the cannon bone, whereas in the breeds improved for meat purposes the femur is relatively long. With breed improvement for meat has also come thickening of the bones. However much a breeder may tell you he is breeding for fine bone, although they may look fine because the whole animal is larger in proportion, the bone itself is actually thicker than in an unimproved type. The unimproved meat animal is long and thin boned, and one of the ways in which you can select your mutton rams when they are run down and out of condition is just to look at the shortness and thickness of their cannon bones.

Another important point in the shape of mutton sheep is the conformation of their loins, and here again a study of the bone and muscle development will help considerably in defining different types. In the early maturing animal the dorsal spine of the spinal column is relatively short, and the back muscle stands out above these spines. On the other hand the relatively unimproved breed will have long spines which will stick out above the level of the muscle, which is long but very shallow and so gives a thin flesh. An early maturing breed, when it is very young, will also be like this, but as it grows up it passes quickly through to the short-spined thick muscle phase of shape. Many late maturing and unimproved animals are not capable of developing to this level, and no matter how you feed them they will not reach it because they have not been properly bred.

One of the qualities we look for in the lamb carcass (when it is cut through at the last rib), is a very deep "eye" or chop muscle, and short spines to the vertebrae. The length of these spines will correspond to the lengths of the cannon bones, and if you get short cannon bones, then you will tend to get the bony spines short also.

Now take the thickness of fat over the chop muscle. This is important, because the butcher wants to sell the chop straight to the customer without trimming it, and so it has to have on it the right amount of fat generally required by the public. If there is too much some will have to be pared off before it is sold, and if there is not enough it will dry up in cooking. The optimum requirement of fat over the chop muscle at the last rib is about 8 mm. in mutton carcasses

at nine months old, but goes down as the carcasses become lighter. The actual measurements in most of the British breeds of sheep at this age have been determined. Some breeds put on a lot of fat and other breeds are difficult to make fat enough. For commercial purposes the latter are usually crossed with rams from the former, and the crossbred is intermediate and near market requirement.

The study of growth in the sheep does not end with the changes which take place in the anatomy or the chemical composition of the animal. There is a change in the microscopic structure of the meat of the animal also as it grows up, and this has an important bearing on the quality of the meat. If, for example, a slice through the muscle of a lamb at birth is compared under the microscope with one when it is five months' old, it will be seen that there is quite a big difference in the structure of the muscle. In the young animal the muscle bundles (the fibres of the muscles are grouped in the bundles) are quite small, and as the animal grows up these bundles become larger and coarser. The size of the muscle bundles determines the grain of the meat. The butcher tests this by running his thumb across the surface of the meat. In an old animal the surface will be coarse and rough-grained, and in a young animal it will be soft and velvety; the latter will be tender to eat and the former will be tough. You will have noticed the large difference in this respect between beef which is coarse-grained and tough, and small young lamb, which has a very fine grain and is tender. The public pays a very great deal of attention to tenderness. I do not know whether teeth in London are quite so good as they were, but they do like tender meat nowadays; the public has a very great dislike for anything tough. The demand there is for the tender meat. That is one of the reasons why young lamb is required; it is so much more tender than the older meat.

The differences in the size of the muscle bundles as the animal grows up is due to increase in the size of the muscle fibres composing the bundles. The muscle fibre of the lamb is very delicate, whereas the same muscle, when it grows older, shows a much coarser and wider fibre. Some muscles have finer fibres than others in the same sheep and will be more tender.

The job of the agricultural scientist is not over when he analyses things and finds out the why and the wherefore. He has to be able to put his knowledge into practical use, and one of the things that has been done in the case of the quality investigations of mutton and lamb, has been to draw up a point system for judging lambs for market requirements. The scale shows the number of marks for each quality point involved, because, if a man is to learn anything from a competition, he must not merely be told that his lamb is not suitable, but you have to tell him exactly why that lamb did not win. He can then see by taking his pointage and comparing it with the maximum, which is his weakest point, and can take steps to remedy it so that next time he may get nearer the mark.

Most of these various points have already been discussed, but two have not been dealt with. The ribs should be light with a high proportion of lean. The butcher has to sell these for very much less than he buys them for; therefore he is interested in getting as small a weight as possible, and the lighter the ribs are in the carcass, the

better he will like it. That does not mean to say that your adult animals should not have good ribs, for the rib development increases with age. In an old bullock (even if it is underfed) the ribs grow long. The quicker you get the animal up to a weight, the smaller will the ribs be in proportion to the rest of the body.

The colour of the muscles in lamb should not be too dark. Colour is important, because it is associated with flavour. Veal that is white is comparatively flavourless, but if you have ever tasted bull beef, which is dark, you will know it is very strong in flavour. There is a happy medium. The bright red colour which we like to see in beef is associated with the average flavour the public likes. The lean meat in lamb especially should not be too dark. The colour of muscle can be increased by the amount of exercise in a lamb. The more the lamb runs about and the less milk it has, the darker will the meat be. Another thing which gives a dark colour to meat is an improper bleeding, due to the lamb having to travel long distance before slaughtering. The quicker it goes from the farm into the slaughter house the better.

The farmer is as interested in the rapidity in live weight growth as in other qualities, and so studies have been made to find out the factors which affect it. Weighing is done with a spring balance, tripod, and slings so that the lambs can be weighed on the field without moving the flock.

An experiment was done in which Shropshire and Merino ewes were not given any extra food during the month or so before lambing, and the lambs were light when born. In the following year, exactly the same ewes were given extra food for about six weeks before lambing, and this time the birth weights, instead of being 7½ lb., were 12½ lb., and the lambs were very much stronger. When the lambs were thirteen weeks old, the ones from ewes which had no feed before lambing weighed only 39 lb., as compared with 67 lb. for those from the ewes which were fed (these were all twin lambs).

That extra food given before lambing helped not only the growth of the lamb itself but also assisted greatly in the development of the udder so that there was extra milk available for the lamb. You will find exactly the same differences between singles and twins, owing to limitations of milk supply for the latter. The ratio between the weight of the single and the twin lamb will widen from birth until about five months old. At about this time the lamb will begin to eat appreciable amounts of food and will supplement the mother's milk with other things; then the ratio between the weight of single and twin will begin to go down again, showing that milk is very important in determining the rate of growth. This can be shown experimentally in the case of rabbits; by allowing does to suckle one kitten instead of five, one can obtain a rabbit three times the size of the others at four months old. These animals were absolutely pure for size, inbred for eighteen generations, and otherwise would be exactly the same size. The difference is entirely due to the different supplies of milk.

The difference in weight between twin and single lambs at any one age gives a measure of the amount of milk supplied by the ewes. If in any flock you see a big difference between the weights of the twins and the weights of the singles, you may know that the mothers are bad milkers. There is a tremendous difference between the breeds

in this respect; it is no good having high fertility and twins in your flock, unless the ewes have plenty of milk. Moreover, you will never have really good rapid maturing fat single lambs, unless the ewes have plenty of milk.

What effect do the different forage crops have on the rate of growth of the lamb? Between those investigated there was not much difference, but there was a tremendous difference in any one crop at different stages of its growth. When the plant is young the lamb will put on about 5 lb. a week; after it has gained the flowering stage, about 2 lb.; and after flowering, when it is beginning to seed, the rate of gain in the lamb will go down to 1 lb. per week. The reason for this is that the plant also changes in composition as it grows up. Take, for instance, the chemical analysis of grass: in the young stage of growth it contains 26 per cent. protein; in the old stage only 10 per cent. Young grass contains very little cellulose (or fibre), but old grass contains quite a lot. The result is that if lambs eat the old plant they merely fill themselves with packing that has very little food value in it; their appetites are satisfied, they lie down, and eat no more. The lamb which eats young grass, on the other hand, gets a high amount of nutriment in small bulk; it remains hungry longer, and eats more, and so its rate of growth will be much faster.

Many of these same principles apply also to milk and butter-fat production in the cow. In the udders of heifers which are preserved, cut through, and stained, the milk producing parts can be seen and distinguished from the fat. The udder of a heifer, before being mated, has fine ducts extending through the fatty tissue. After the animal has been mated, and is three months in calf, no differences are seen, but suddenly, at five months pregnant, a great change occurs. The ends of the ducts begin to swell up to form the milk-producing gland, and you can obtain from the teats, instead of a watery fluid, as heretofore, a thick honey-like secretion. By the following month, (6th), the gland part has grown enormously and is replacing most of the fat.

When you give extra food of the right sort (high in protein) to your animal during the late stages of pregnancy, whether it be a ewe or a heifer, you encourage growth of this gland tissue, and therefore you will get more milk after the young are born, because the amount of milk given depends on the amount of this gland tissue grown before calving. And in many cases where animals are let go back in condition during the later stages of pregnancy, full development of the gland does not occur, and you will get very little milk after calving.

If a cow is already in milk, you will find that, at about the fifth month of pregnancy, the milk yield begins to fall off suddenly, for a cow cannot both grow udder gland tissue and give milk to the fullest extent at the same time. She will usually split the difference and do some of each. If you milk her right up to the time she calves, you will not get as much milk in the next lactation as you would if you left her dry for some 40 days. You will not get the same development of the udder if you milk her right up to before calving, because, as she is giving milk, her udder gland tissue has not the chance to grow to the fullest extent.

You can also make this udder gland tissue grow by giving an injection. But this is at present not a paying proposition because the extract injected—anterior pituitary gland extract—is expensive. By

injecting this extract into a heifer that has never been in calf, you can, in a few weeks, get a large udder development and milk just as though she had produced a calf.

When one studies the shape of the curve of lactation in a cow, one can see how much seasonal conditions affect the milking qualities of the animal; for example, cows that calve in the spring, when the grass is young and succulent in England, come in on a very high level of production, and they will milk well at first but they begin to fall off rapidly as the grass begins to reach the fibrous stage. On the other hand, cows calving in the autumn months on dry hand feed, do not give anything like as much as the others when they first come in, but later, when they are turned out into the young spring grass there is a great increase in the rate of milk production. These late autumn calving cows give a greater amount of milk in the lactation than do the spring calving cows in England.

If you could run the whole lactation of a cow in any one month of the year (which you can do by making calculations), you would get very much more milk under the spring conditions of young succulent feed than you would under the dry feed winter conditions.

The trouble with our milk production in England, which is mainly to supply milk to cities, is that one gets too much in the spring and not enough in the winter, and it is the object of the farmer there to avoid this. He is doing it by cutting the feed during the spring flush and making silage and hay. Lately, too, an apparatus for drying young grass in the very succulent stage has been investigated. The peak period of grass growth is also of importance from the point of view of the butter-fat producer. By calving before the flush of the grass occurs, he can take full advantage of this natural food. The mammary glands of a cow will be active and ready to produce at the same time as the food is available. If, on the other hand, the cow is in full profit when natural food is short, the maximum production is not obtained. Details concerning this want working out for all your districts here. There should be a certain month of calving at which you will be able to get from your cows a higher and more economical production than in any other calving month.

Another investigation has taken place in England concerning the causes of the disposal of dairy cows. Our dairy farmers were very much disturbed by the number of cows being turned out of the herds each year, and the number of heifers it took to replace them. So we made an investigation to find out the causes. The only cause I will refer to now is that of low milk yield. About 20 out of every 100 are being turned out because of low yield, and the reason for this we can trace mainly to the bulls in use.

For instance, in a certain herd, the owner would never keep any cow in his herd that would not yield above 6,500 lb. of milk. Some of the cows he bred to one bull, with the result that he got daughters all below the average, only three having yields good enough to go into the herd. On the other hand, in the same herd, many of the same cows were mated to another bull, and in that case it was found that there was only one daughter that had to be rejected—all the others came above the level of their mothers. We are therefore now paying particular attention to the bull used.

"Progeny tests" are being made of bulls, and those which come out well are being retained as long as they will breed. Progeny tests are applicable not only to milk records, but also to the uniformity and appearance of the bull's daughters.

I do not think I can press the point of progeny breeding tests too much. The appearance of an animal is not always a hall-mark of perfection in breeding. It is only by continuous selection and progeny testing, of your males particularly, that you will be able to continue to improve the breed, and this applies particularly to all English mutton breeds of sheep. You cannot maintain the good qualities of a breed except by rigorous selection. Most countries have had to go from time to time to the original source of the breed for fresh blood, but some countries are finding that they can maintain their breeds, and in fact even improve on the countries from which their stock came. When you look into it, you will find their method of improvement has been to select their animals in a good environment. For example, in the Argentine they now have beef-bull breeding farms, where the bull calves are reared in the lap of luxury. A whole herd of dairy cows is kept to feed the young bulls, which are given milk till they are fifteen to eighteen months old. If they do not grow and develop well on that, they are rejected. As a result of this procedure, Argentine needs go to England for fresh stock only every now and again. Formerly she used to buy hundreds from England to keep her stock on the estancias going.

In meat-producing animals, the breeder's secret is to feed them well, in a proper environment, and select those which respond to this treatment.

Discussion.

In the discussion which followed the meeting, Dr. Hammond dealt with many questions relating to fat lamb production. He put before the audience the Southdown as the best sire of a high quality sucker lamb and as the dam a crossbred ewe of good conformation and milking capacity, whose wool producing qualities should not be overlooked, as these should pay for the keep of the ewe. Progeny of such a cross marketed as sucker lambs was what the London market required.

He was well aware that lambs of lower quality produced from other crosses and by other methods had met with a highly profitable market, but this state of affairs was unlikely to continue. His advice to Australian producers to concentrate on a high quality sucker lamb was not given with the suggestion that they would by this means make very much more money than in the past, but that only by doing so would they hold their share of the English market.

A Progress Report on a Sheep Rugging Trial at "Brae Springs," Albury, New South Wales.

*By Ian W. Montgomery, B.V.Sc.**

Summary.

1. Rugging of sheep for wool improvement and the maintenance of health has attracted considerable attention from graziers of New South Wales and other States.

2. A trial is being conducted in the Albury district where the effect of rugging on the wool produced and on the body weight of sheep is being studied.

3. During the experimental period, there was an abnormally low rainfall and practically no dust or burr contamination of wool.

4. No significant difference was recorded between the rugged and unrugged groups in any of the observations made.

5. A difficulty in estimating the true value of wool from rugged sheep by wool classers was recorded.

6. Rugging is very unlikely to be economical under conditions of low rainfall and moderate temperatures in the absence of burr and dust.

7. It is suggested that similar observations should be carried out where cold winters are experienced or where dust and burr contamination of wool occurs.

8. All experimental results should be determined on a clean scoured basis.

1. Introduction.

It must be emphasized that the following report, as regards the economic aspects of rugging, applies only to the particular circumstances of rainfall, moderate winter temperatures, and comparative freedom from dust and burrs under which this trial was conducted. The report offers no criterion of the economies which may be effected by rugging under more adverse conditions, and must on no account be taken as a condemnation of rugging on economic grounds or as an expression of opinion on the general question of rugging. The report has application to a particular set of conditions and to those conditions only; moreover, it covers only the first twelve months of a trial which is still in progress.

2. Notes on the Results obtained in the First Twelve Months.

The experiment is in progress in the Albury district, and an endeavour is being made to determine the commercial value of rugging and other factors which may, or may not, make the general rugging of flock sheep an economical procedure.

* Formerly Veterinary Officer to the "Grazcos" Veterinary Club, during which period he organized this trial in co-operation with the F. D. McMaster Animal Health Laboratory, Sydney; subsequently appointed under a grant from the Australian Wool Board as a Field Research Officer in veterinary parasitology with temporary headquarters at the McMaster Laboratory.

The property on which the work is being done is situated about 20 miles north-east of Albury on the edge of the wheat belt, is typical of good wool-growing country producing reasonably clean wool, and is representative of a large area of New South Wales. If rugging is an economical procedure in this district, it may be of definite value throughout the Commonwealth. If, however, it is uneconomical, rugging may then be a satisfactory procedure only under special conditions such as obtain in dusty, burry, cold, or deficient areas. The average annual rainfall of the district is 26½ inches, and the sheep are running on good natural pastures and occasionally on improved pastures. The property is well improved, of granite origin, and is flat to undulating.

The original experimental sheep were a group of 250 selected by a sheep classer for uniformity from a mob of 1,000 Comeback (Polwarth blood was originally in the flock) wether hoggets, fourteen months old. The sheep were weighed prior to the commencement of the experiment and are weighed and examined every three months.

The following particulars were recorded prior to the selection of the experimental groups and will be recorded at each shearing during the course of the experiment:—

1. Body weight.
2. Weight of fleece wool.
3. Weight of belly wool.
4. Weight of pieces.
5. Total fleece weight.
6. Wool spinning count.
7. Estimated percentage clean-scoured yield.
8. Commercial line of wool.
9. Presence or absence of fleece rot.

The figures are tabulated on a card system, kept at the McMaster Laboratory for statistical purposes.

From the original 250 sheep, 96 pairs were selected, each pair being uniform for body weight, estimated clean-scoured fleece weight, and spinning count. One from each pair was rugged and the other unrugged, the allocation to groups being done at random. Any sheep showing signs of fleece rot or tender fleece were omitted. Uniform groups were thus obtained and are being run together and submitted to the same management procedures.

During the course of the experiment, the following particulars are being recorded:—

1. Rainfall, including type and number of falls per day.
2. Incidence, severity, and site of fly strike.
3. Incidence and site of rug tears.
4. Any signs of internal parasites, the presence of which will be checked by the examination of faecal samples selected at random from ten of the rugged and ten of the unrugged group.

5. At shearing time a sample of wool is taken from the shoulder at the middle of the spine of the scapula for fibre determination.
6. Ten 2-lb. samples of wool are taken at random from each group for a check determination of the clean-scoured yield.
7. Costs involved in the procedure of rugging are being determined.

At the conclusion of the first year of the experiment, twenty of the rugged group were changed over to the unrugged group and vice versa to determine if the change over has any effect on the wool. Twenty pairs were selected at random and interchanged.

3. Notes on Records obtained at First Shearing (Table 1).

The classer's general comment was as follows:—"Rugged sheep showing an increased length of staple, more bulk and body, denser in staple, more character, more condition." In spite of this favourable comment, it will be noticed that the valuations of the rugged fleeces are lower than the unrugged fleeces. This is due to the fact that the valuers have the opinion that the yield of rugged fleeces is 5 per cent. to 8 per cent. lower than the unrugged fleeces. A mean taken of yields given by the valuers to the individual fleeces of each group shows a difference of 1.42 per cent. in favour of the unrugged group. A scouring test showed that there was no significant difference between the degree of accuracy with which individual rugged and unrugged fleeces were yielded. However, when the wools from each group were massed together on the floor, the unrugged wool appeared much brighter than the rugged wool, which had a distinct yellow appearance that would indicate to a buyer a lower percentage yield. The wool was specially catalogued and sold separately, and it is apparent that buyers who base their estimates on their experience may under-estimate the yield of rugged wools until experience with this class of wool is obtained.

It will be noticed from Table 1, which tabulates the results of the first year, that the total weight of wool in the fleece lines in the rugged group is 43½ lb. lower than in the unrugged group, while the weight of the rugged BKN is 24 lb. higher than the unrugged BKN. This indicated that heavier skirting is necessary in rugged sheep in this class of country in order to present a uniform line of wool to the buyer. Generally, a greater proportion of the neck had to be removed.

Fleece Rot.—There was a total absence of this condition in both the rugged and unrugged groups, although 10 per cent. of the original 250 sheep examined were affected. The affected sheep were all eliminated before the commencement of the trial. The rainfall figures were over 6 inches below the corresponding period of the previous year, which itself was an average year with a total fall of 26½ inches.

Fly Strike.—This was negligible, one sheep in each group being struck. The rugged sheep lost its wool, the unrugged produced the only tender fleece.

TABLE 1.—TABULATED RECORD OF RESULTS OBTAINED AT FIRST SHEARING.

Class of Wool.	Classers' Comment.	Yield.†	Weight.	Valuation, 21.9.37.	Selling Price, 11.11.37.	Total* Price Received.
		%	lb.	d.	d.	£ s. d.
AAA rugged ..	64's shafty super fleece, bulky, good length, free ..	..	292·04	23¼	17¾	21 12 0
AAA unrugged ..	64's–70's spinners, good shafty fleece, free ..	..	336·85	24	17½	24 11 3
AA rugged ..	64's spinners, average fleece, free	..	256·19	21½	17¼	18 8 3
AA unrugged ..	64's–70's spinners, good fleece, not quite as shafty, bit thin, free	..	254·81	22¼	16¼	17 5 1
BKN rugged ..	64's and upwards, good BKN and 1st pieces suitable for spinners, free	63	170	20¼	16½	11 13 9
BKN unrugged ..	64's and upwards, good BKN and 1st pieces suitable for spinners, free	64	146	20½	16½	10 0 9
A. Pcs. rugged ..	64's–70's, fair length pieces, free or nearly free ..	56	134	17	13	7 5 2
A. Pcs. unrugged ..	64's–70's, fair length pieces, free or nearly free ..	57	142	17¼	13	7 13 10
Bellies rugged ..	64's, good bellies, combing length, practically free ..	50	68½	15¼	11¼	3 4 3
Bellies unrugged ..	64's, good bellies, combing length, practically free	52	69	15½	11¼	3 4 8
Stained rugged ..	60's–64's, good stained pieces, fair length, free or nearly free	48	32	11	Not Sold.	..
Stained unrugged ..	60's–64's, good stained pieces, fair length, free or nearly free	48	33½	11	Not Sold.	..
Locks rugged ..	Good quality locks, fair bulk and colour, free or nearly free	44	84	10	7¾	2 14 3
Locks unrugged ..	Super locks, good colour, medium to good bulk, free ..	46	79	10½	7¾	2 11 0

* Only the fleece lines were offered for sale separately, the remaining lines being very similar were sold together. Sale was made on a falling market with no competition.

† Individual fleeces were yielded in the fleece lines.

TABLE 2.—SUMMARY OF RESULTS OBTAINED IN FIRST TWELVE MONTHS.

Group.	Shearing Date.	Average Body Weight.	Total Weight of Fleece Wool Cut.	Average Yield of Fleece Wool.	Total Weight of all Wool Cut.	Total Value of all Wool.*
		lb.	lb.	%	lb.	£ s. d.
Rugged ..	1936	55·79	311·33	67·88	474·71 (excluding locks)	..
	1937	87·63	548·23	62·78	1037	65 7 8
Unrugged	1936	55·09	311·33	67·73	473·96 (excluding locks)	..
	1937	89·82	591·67	64·2	1061	64 16 7

* The sale of the wool prior to the commencement of the experiment was not considered in deciding on the experimental groups. Stained pieces have not been sold in either group from the 1937 shearing.

(i) *Statistical Report.*

A statistical report has been drawn up from the figures obtained at the shearing at the end of the first twelve-month period of the experiment.

Discards.—Three pairs of animals were omitted in the final analysis, owing to the death, or accident to the wool, of one member of the pair. This left 93 pairs of animals for consideration.

1. *Total Cuts per Head.*—The rugged group cut 10.27 (± 1.08 lb.) of wool per head, and the unrugged group 10.64 (± 1.12 lb.) there being thus no significant difference between the two.

2. *Spinning Count.*—The rugged group contained 66 animals having a spinning count of 64's or under, and 27 with a count of 64/70's or 70's. The unrugged group contained 57 animals in the 64's and under group, and 36 in the 64/70's and 70's group. There was thus no significant difference between the groups.

3. *Commercial Line.*—Two classes were made, AAA and AA. The rugged group contained 50 AAA fleeces and 43 AA's, while the unrugged contained 53 AAA's and 40 AA's. Again there was no significant difference between the groups.

4. *Fleece Weight by Commercial Lines (i.e., Skirted Fleeces only, excluding Bellies and Pieces).*—The 50 AAA fleeces in the rugged group gave 292 lb. of fleece wool, while the 53 AAA's in the unrugged gave 337 lb. The 43 AA's in the rugged group gave 256 lb. of fleeced wool, and the 40 AA's in the unrugged 255 lb. These differences are largely accounted for by the heavier skirting required in the case of rugged sheep as mentioned above.

(ii) *Scouring Trial.*

As a check on the classers' yields of the rugged wool, ten 2-lb. samples of wool were taken at random from each of the rugged and unrugged groups in the fleece lines. These were brought to the laboratory and their yield estimated by a second classer. Each sample was then weighed at room temperature and humidity, and subsequently

scoured. The scoured samples were first dried overnight in a hot room at 38°C. and subsequently at 70°C. for 24 hours, and were then allowed to condition for 24 hours at room temperature and humidity, being weighed at 2, 7, and 24 hours. The weight at this time, namely after 24 hours, expressed as a percentage of the original weight, was taken as the true yield. Table 3 shows the results.

TABLE 3.—COMPARISON OF CLASSERS' ESTIMATES WITH TRUE YIELD.

Rugged Samples.				Unrugged Samples.			
Sample Number.	Percentage Yield Classer D.*	Percentage Yield Classer M.†	True Percentage Yield.	Sample Number.	Percentage Yield Classer D.	Percentage Yield Classer M.	True Percentage Yield.
1	64	70	68	11	70	66	67
2	66	64	69	12	60	65	62
3	65	66	65	13	68	58	65
4	63	66	65	14	68	62	65
5	65	64	64	15	64	68	63
6	58	62	61	16	64	66	63
7	68	69	65	17	58	60	55
8	60	65	58	18	68	56	56
9	64	66	60	19	60	62	61
10	64	68	72	20	63	66	67
Mean	63·7	66·9	64·7	...	64·3	62·9	62·4

* Classer D. was at Albury.
† Classer M. was at Sydney.

The mean deviation from true yield among the rugged sheep for Classer D was — 1.0 ± 1.16 per cent., and for Classer M + 1.3 ± 1.21 per cent. Amongst the unrugged sheep, the mean deviation for Classer D was + 1.9 ± 1.36 per cent., and for Classer M + 0.5 ± 1.19 per cent. Statistical analysis of these results indicated that the mean estimated yield of a group of ten fleeces might be expected to be accurate to within 2½ per cent., but the estimate on a single fleece might be as much as 8 per cent. out. There was no tendency for either classer to be consistent in his errors.

(iii) *Rainfall.*

Rainfall figures for the 12 month periods were as follows:—

(*a*) Shearing 1935 to shearing 1936—27.07 inches.

(*b*) Shearing 1936 to shearing 1937—20.97 inches.

For the second period, records are available of the number of falls and types of falls that have occurred.

(iv) *Rug Design.*

All rugs were examined and the situation of the tears was recorded to determine the weaknesses in the present design. With 96 sheep rugged, 82 rugs were torn and 11 rugs had to be replaced. There was a total of 121 tears. Forty-four per cent. of the tears were on the front leg-hole and 28 per cent. in the brisket strip. Twenty per cent. of tears occurred at the junction of the rear leg strap and the rug, and the remaining 8 per cent. on the side of the rug.

As a result of this examination, it was decided that the inclusion of arm holes and a brisket piece is undesirable, and that the rug should be of a simpler pattern with a longer back roll (increased from 8 inches to 12 inches or 14 inches) and possibly a roll may be made in the neck piece. In the rugs now being used, the brisket piece and front arm holes have been eliminated.

4. Discussion.

Before this experiment was commenced little was known of the general effect of rugging on wool production and body weight. It was conceivable that rugging might be economical wherever sheep were raised. In order to examine this question, the above trial was commenced, not on our best wool growing country but on reasonably clean country in a temperate area, representative of a large proportion of the New South Wales wool-growing districts. Heavy burr and dust contamination and extremes of cold were avoided, in order to prevent too many factors from entering into the consideration of the final result.

The experiment in its present stage suggests that rugging will prove uneconomical under temperate conditions and in the absence of dust and burr. Further experimental work is required to show what economical return would be obtained where heavy contamination with dust or burr is encountered, particularly when fine wool production is aimed at.

Another field for exploration of the economic aspects of rugging is in cold country such as the New England tablelands and the Monaro. It is conceivable that the protection it offers from cold and the consequent maintenance of body heat would allow much of the food consumed to be diverted to other purposes resulting in greater wool production, maintenance of body weight, and a higher percentage of better lambs. Such benefit is more likely to occur where sheep are running on cold table-land country with scanty winter grazing.

In many instances it may only be necessary to rug the sheep for the portion of the year when cold, dust, or burrs are most troublesome. If this be so, and since the greatest cost of rugging is in rug depreciation, the increased "life" of the rug thus procured would effect a very considerable saving in costs.

Rugging experiments are therefore considered desirable on the table-land country and in dusty and burry country, consideration being given to rugging for a portion of the year only.

In future work, comparison of staple length of fleeces produced by rugged and unrugged sheep is required. In all trials the classer's estimate of yield should be checked by determination of clean-scoured yield on representative samples of the wool produced.

Experimental work in table-land country would be far more valuable if carried out with breeding ewes in order that the lambing percentage and growth rate of lambs from rugged and unrugged groups may be compared.

5. Acknowledgments.

It is desired to express great appreciation to Mr. K. McRoberts who has made his property and sheep available for the conduct of this trial and without whose ever-willing assistance the work could never have been performed, and also to Dalgety and Company Limited, Albury, who made available wool classers for the examination of the fleeces.

Mr. C. A. Copeland, of Smith Copeland and Company Limited, has presented the rugs used in the trial, and at the conclusion of the first twelve months presented a complete new set of rugs of the improved design. To him our thanks are due.

The Graziers' Co-operative Shearing Company assisted by making time available to me when the experiment was commenced under the auspices of their Veterinary Club. This company also assisted in the shearing arrangements.

Dr. I. Clunies Ross, former Officer-in-Charge of this Laboratory, and Mr. D. A. Gill, the present Officer-in-Charge, have at all times given assistance and helpful suggestions in the conduct of the experiment. Mr. N. P. H. Graham has carried out a large part of the work involved, visiting the property three times. He carried out the routine examinations and assisted in dealing with the shearing observations. Mr. Munz of the McMaster Laboratory has conducted the scouring trial. Miss H. Newton Turner's statistical work is shown in the body of this report. To all these I desire to express my grateful appreciation.

The Effect of Rugging on the Milk Production of Merino Ewes and on the Growth of their Lambs.

*By A. W. Peirce, M.Sc.**

Summary.

Under the conditions of management and climate at the Waite Agricultural Research Institute, Merino ewes bred from stock from the Mid-North of South Australia did not show an increase in the production of milk as the result of rugging. The lambs of the rugged ewes, likewise, did not grow more rapidly than did those of similar unrugged ewes.

1. Introduction.

The practice of fitting rugs of bag or canvas to sheep, introduced into South Australia in 1934 by Mr. Spen Williams, has spread, not only in this State but in other parts of the Commonwealth. It is claimed that rugging reduces the deterioration of parts of the fleece, particularly along the back, and results in an increased monetary value of the wool. In addition, it is suggested that if smaller amounts of poor quality wool came on the market the price of the remaining wool would be more satisfactory to the grower. An account of the early experiments on the rugging of sheep in South Australia has been given by Scott (1935).

The extent to which rugging reduces deterioration will obviously depend on managerial and climatic conditions. Where sheep are exposed to dust or sand, or where the annual rainfall is heavy, it is probable that the increased value of the fleece will exceed the cost of the rug. Under less severe conditions, the return for the wool may be no greater with rugged than with unrugged sheep, as was found at the Waite Agricultural Research Institute during 1935-37 (unpublished data).

It is also possible that rugging may be valuable in districts where cold conditions are experienced in the first few weeks after shearing. This aspect of the question of rugging does not appear to have attracted much attention.

Some of the advocates of rugging have claimed that the lambs of rugged ewes grow more rapidly than those of unrugged ewes. This seems to imply an increased production of milk by the former sheep. It was with the object of studying the effect of rugging on milk production and on growth of lambs that the present experiment was undertaken.

2. The Experiment.

Twenty-four Merino ewes from the breeding flock maintained at the Waite Agricultural Research Institute by the Division of Animal Health and Nutrition were fitted with rugs immediately after shearing

* An officer of the Division of Animal Health and Nutrition located at the Nutrition Laboratory, Adelaide.

in September, 1936. Each of these animals was matched against a sheep of the same age which had produced and reared satisfactorily the same number of lambs. The two groups of sheep grazed together in the same paddock as the remainder of the breeding flock. All the ewes were joined with the rams in November, 1936.

At lambing, which began in April, 1937, the lambs were weighed soon after birth and then ear-tagged. The ear number of the mother of each lamb was noted. When the lambs were approximately a fortnight old, the yield and composition of the milk of six rugged ewes and their controls was determined by the method which has previously been employed [Peirce (1936)]. The total yield was measured over two periods each of 24 hours, separated by an interval of the same duration. Samples of the milk from each ewe were examined for fat, total protein, total solids, and specific gravity.

The lambs from the ewes of both groups as well as those from the remainder of the flock were weighed weekly, but it is only necessary to consider the growth for the first three months. After this time only a small proportion of the lamb's food requirements is derived from its mother's milk, and indeed some ewes are dry by then.

The rugs were left on the ewes until shearing, but, as the sheep were not matched originally for wool production, no mention will be made of the amounts of wool grown. This experiment, moreover, was not concerned with wool production, but only with milk production and the growth of lambs.

3. Results.

(i) *Production of Milk.*

The percentage composition, the specific gravity, and the calculated energy value per gm. of the samples of milk from six ewes of each group, taken at the end of the second week of lactation, are set out in Table 1. This table also contains the calculated daily production of milk, fat, protein, solids, and energy by each of the ewes. The energy values of the milks were calculated by the formula given by Overman and Sanmann (1926) for cows' milk—Cals. per U.S. quart = 52.78 × % fat + 16.41 × % protein + 37.87 × % total solids + 46.91 × specific gravity — 2.75 × % lactose — 57.70. It was found [Peirce (1934)] that values so calculated did not differ by more than 2 per cent. from those obtained by direct combustion of ewes' milk. Lactose was not estimated in the present work, but for the calculation it was assumed that each sample of milk contained 4.76 per cent., the average of all the determinations previously carried out here on ewes' milk. It is unlikely that any appreciable error was introduced by this assumption, as the percentage of lactose is remarkably constant in different sheep and at different stages of lactation. (The range in 27 samples of milk was 4.42 to 5.00 per cent. Furthermore, when the calculation is made by the formula of Overman and Sanmann, the lactose contributes directly but a small portion of the total energy, about 1 per cent.

It will be seen that the milk of the rugged ewes was slightly superior to that of the controls in total amount, in energy value per gm., and in percentages of fat and total solids, but it was inferior in percentage of protein. The total daily production of fat, solids, and calories, by

TABLE 1.—CHANGES IN THE PERCENTAGE COMPOSITION AND DAILY YIELDS OF THE VARIOUS COMPONENTS OF MILK AS THE RESULT OF RUGGING EWES.

Group.	Rugged.							Unrugged.							
Sheep.	$W_2$48.	W_{3B}77.	$W_4$14.	$W_5$47.	$W_6$130.	$W_7$321.	Average.	$W_2$35.	W_{3B}17.	$W_4$23.	$W_5$17.	$W_6$128.	$W_7$320.	Average.
Composition.	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Fat	5·73	7·26	12·79	9·20	7·16	7·84	8·33	7·30	8·11	7·96	7·10	6·24	6·36	7·18
Protein (N x 6·38)	4·92	4·14	4·93	4·32	4·68	4·37	4·56	5·28	4·36	5·22	4·74	4·89	4·11	4·77
Total solids	16·53	17·22	23·23	18·89	17·30	18·28	18·57	18·38	17·82	19·04	17·53	16·87	16·45	17·68
Specific gravity	1·037	1·032	1·028	1·031	1·034	1·035	1·033	1·037	1·032	1·035	1·032	1·038	1·040	1·036
Energy (Cals. per gm. milk) ..	1·00	1·11	1·66	1·28	1·11	1·18	1·22	1·17	1·18	1·23	1·12	1·04	1·02	1·13
Daily Yield.	gm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.
Milk	1,490	940	1,020	900	1,300	1,220	1,140	1,070	1,240	1,010	900	1,130	1,010	1,060
Fat	85·4	68·2	130·5	82·8	93·1	95·6	92·6	78·1	100·6	80·4	63·9	70·5	64·2	76·3
Protein	73·3	38·9	50·3	38·9	60·8	53·3	52·6	56·5	54·1	52·7	42·7	55·3	41·5	50·5
Total solids	246·3	161·9	236·9	170·0	224·9	223·0	210·5	196·7	221·0	192·3	157·8	190·6	166·1	187·4
Energy (Cals.)	1,490	1,043	1,693	1,152	1,443	1,439	1,377	1,252	1,463	1,242	1,008	1,175	1,030	1,195

TABLE 2.—THE EFFECT OF RUGGING EWES ON THE GROWTH OF THEIR LAMBS FOR THE FIRST THREE MONTHS.

Weeks.	Birth.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Average weight of eighteen lambs from rugged ewes (kg.)	4·4	7·0	9·0	11·1	12·6	14·6	15·8	17·4	18·6	20·2	21·1	22·5	23·3	24·3
Average weight of eighteen lambs from unrugged ewes (kg.)	4·3	6·7	8·9	10·7	12·3	14·0	15·4	16·9	18·5	19·8	20·9	22·1	23·3	24·3
Average weight of all lambs (50) of the 1937 drop (kg.)	4·3	6·9	9·1	11·1	12·6	14·5	15·9	17·5	18·9	20·3	21·4	22·7	23·8	24·7

the rugged ewes was greater than that by the controls, but the differences were not significant. On the other hand, the total daily yield of protein, which one might consider the most important single factor in the growth of young animals, was the same in both groups.

(ii) *Growth of Lambs.*

Some of the sheep in the experiment did not raise lambs. Three rugged ewes failed to lamb, another was unable to rear its lamb, while the offspring of the fifth died at the age of three weeks. One control ewe did not lamb. Consequently, only eighteen pairs of lambs were available for comparison. The total number of lambs remaining at the end of three months in the whole breeding flock of 60 ewes was 50.

The average weekly weights, for the first three months, of the lambs from the rugged group, from the control group, and from the whole flock are set out in Table 2. Differences of sex were disregarded, as it has been found previously (Peirce, unpublished work) that during the first three months of life the growth rates of rams, wethers, and ewes are the same.

No differences were observed in the rates of growth of lambs from the rugged ewes, from the control ewes, and from the whole flock.

4. Discussion.

It is reasonable to expect that rugging could only bring about an increased yield of milk through reduction of energy losses by insulating the animal against unfavorable climatic conditions. The ewes, however, were mated in November, about two months after shearing. Consequently, before lambing began all the ewes had grown sufficient fleece to provide a much better insulating cover against cold than could be supplied by a rug. The insulating power of the fleece against rain was also considerable, as it rarely happens that rain penetrates entirely through a fleece of six or more months' growth on sheep of this type.

It should, therefore, occasion little surprise that the rugging of these ewes had no effect on their milk production or on the early growth of their lambs.

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Cape Tulip, *Homeria collina* Vent. var. *aurantiaca* Sweet.

Life History Studies.

*By A. B. Cashmore, B.Sc.**

Summary.

The life history of Cape tulip, a poisonous weed of pastures in some parts of southern Australia, was studied in pot-cultures at Canberra in 1936. The investigation was undertaken to obtain indications of the growth stage at which weed control methods might be applied most effectively in the field.

It was found that the underground reserves of Cape tulip were at their lowest level, and leaf production had reached its maximum, at flowering, suggesting that weed-killer and cultivation or mowing treatments should be applied at this time.

Cape tulip did not respond in yield to applications of phosphatic and nitrogenous manures. Wimmera ryegrass, a valuable pasture grass, did respond to both when grown under similar conditions and at the same time. This indicates that raising the soil fertility level in the field, together with the introduction of suitable pasture plants, is worth investigation as a phase of the problem of the control of the weed.

1. Introduction.

Field experiments were commenced near Clare in South Australia in 1934 to determine the effectiveness of weed-killers, cultivation treatments, and pasture plant competition in the control of Cape tulip, an introduced poisonous weed infesting natural pastures. To permit the designing of critical experiments, information was required concerning the growth characteristics of the plant. A life history study designed to provide this information was carried out in 1936 in the glasshouses of the Division of Plant Industry at Canberra. Two related experiments were conducted. The first was designed to study the normal growth curve and to determine the stage of growth when control measures might be applied most effectively in the field; the second was designed to measure the response of the weed to applications of phosphatic and nitrogenous manures in comparison with the response of a useful competing pasture species, Wimmera ryegrass. The results of these pot-culture investigations are reported below.

2. Methods.

Supplies of Cape tulip corms were obtained from the field at Clare for use in this work. In the life history series, 85 enamelled iron pots, 9 inches in diameter and 15 inches in depth, were used. The pot weights were standardized by adding gravel and then 15 kg. of clean, sieved, and thoroughly mixed river sand was added to all pots. 100 ml. of nutrient solution, as used by Ballard (Ballard, L.A.T., *Aust. J. Expt. Biol. & Med. Sci.* **11**: 164, 1933), but containing 1 gm. of $NaNO_3$, was given to all pots, and the water level brought to 30 per cent. water-holding capacity of the sand throughout. This water level was maintained during the course of the experiment. On 1st June 80 pots were planted with corms, three per pot. Sample corms were selected at random for the determination of mean dry weight. Five pots were reserved

* An officer of the Division of Plant Industry.

unplanted as controls, for the purpose of measuring actual transpiration losses. On 18th June a mulch of clean gravel screenings was added to all pots to reduce the loss of water by evaporation from the sand surface. The first harvest was made on 1st July and subsequent harvests at fortnightly intervals until maturity. At each harvest, five pots, distributed at random within five blocks in the glasshouse, were taken, so that fifteen plants were available at each stage for determinations of green and dry weights of the different plant parts.

In the manurial series the pots were filled and treated as before, except that phosphorus and nitrogen were omitted from the general nutrient solution given. Sixteen treatments, involving applications of phosphatic and nitrogenous manures at three different levels of each and in all possible combinations, were applied on 10th June. In preparation for planting, Wimmera ryegrass seeds were sown in river sand on 26th May, and on 11th June Cape tulip corms and ryegrass seedlings were planted three per pot. Sixty-four pots were planted with each species, made up of four replicates of sixteen treatments in each case, and the pots were randomized within four blocks in the glasshouse. A gravel mulch was added to all pots on 16th June and the series maintained at 30 per cent. water-holding capacity of the sand. All plants were harvested as they matured, at the time of splitting of the seed capsules.

3. Results.

(*a*) *Life History Series.*

The results are shown in Table 1 and illustrated in Fig. 1.

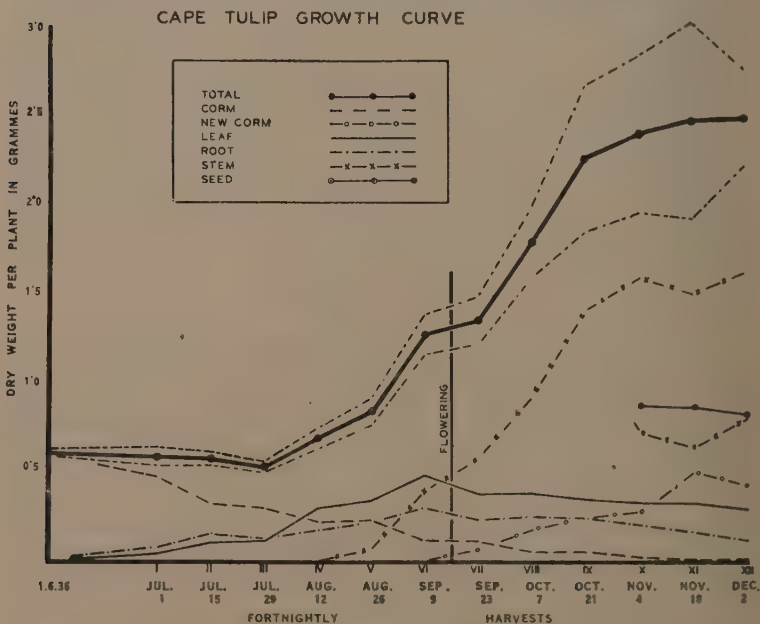

Fig. 1.—Showing the cumulative growth curve of Cape tulip from planting of corm to maturity.

Table 1.—Cape Tulip Life History Series, 1936. Planted 1st June. Yields per Plant in Grammes. Oven-dry Material.

		I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
	1.6.36.	1.7.36	15.7.36	29.7.36	12.8.36	26.8.36	9.9.36	23.9.36	7.10.36.	21.10.36	4.11.36	18.11.36	2.12.36
Old corm	0·59	0·46	0·31	0·29	0·21	0·22	0·11	0·11	0·05	0·05	0·02	T	0·01
New corms	..	..	..	..	..	..	T*	0·06	0·17	0·24	0·27	0·49	0·42
Leaf	..	0·04	0·10	0·11	0·29	0·33	0·47	0·37	0·37	0·34	0·32	0·32	0·29
Roots	..	0·07	0·15	0·11	0·14	0·17	0·25	0·20	0·22	0·22	0·19	0·16	0·12
Storage roots	..	..	..	0·01	0·03	0·04	0·04	0·02	0·02	0·01	0·01	T	..
Stem	..	..	..	..	..	0·06	0·38	0·56	0·90	1·38	0·71	0·63	0·79
Seed	..	..	..	..	..	..	..	..	..	..	0·86	0·85	0·81
Total	0·59	0·57	0·56	0·51	0·67	0·82	1·25	1·33	1·77	2·24	2·38	2·46	2·48
S.E. Total (gm.)	0·02	0·05	0·04	0·03	0·06	0·07	0·11	0·13	0·20	0·41	0·44	0·55	0·27
S.E. Total (%)	3·49	8·78	7·14	6·27	8·85	8·76	8·80	10·08	11·47	18·15	18·61	22·44	11·08
Transpiration ratio ..	..	..	..	11	59	110	98	158	184	221	266	298	309

* T = Trace.

In Fig. 1, the "total" curve is bounded by broken lines representing the standard error on each side of the plotted means.

Reference to Table 1 and Fig. 1 shows a continuous loss in dry weight of the corm throughout the growing season. The production of leaf and root increased steadily until flowering, after which a gradual decline in dry weight occurred in both. Stem production began some three weeks prior to flowering. The stem grew rapidly, the dry weight of stem and developing seeds increasing to a maximum in late October, some six weeks after flowering. In Fig. 1 the mean dry weights of stem and of seed are plotted separately at the last three harvests when the seed had matured, but the curve for stem plus seed is given also. The yield of seed, 0.81 gm. at the final harvest, was equivalent to 526 seeds per plant. During August and early September, while depletion of the reserves in the corm continued, the first evidence of new corm production was seen, and associated with the developing corms, at the base of each leaf, were found swollen structures, which have been called "storage roots." These are rigid, white, fleshy roots without root hairs and apparently function simply as temporary storage organs while the new corms are forming. As maturity is approached and the complete development of the new corms occurs, these structures disappear (Table 1). In Fig. 1, the storage roots are included with "roots." Very few cormlets were produced, a characteristic that in part distinguishes this species from *Homeria miniata* Sweet, in which prolific cormlet production is usual. Occasional cormlets were found in the October to maturity period but never in sufficient numbers to warrant a separate estimation of their numbers or dry weight. They are grouped with "new corms" in Table 1 and Fig. 1.

The flowering stage is the interesting point in the life history of Cape tulip from the point of view of control. At flowering, the development of new corms is beginning and the original corm is practically exhausted of its reserve materials, while the amount of leaf and presumably leaf area have reached their maxima. It would appear that this is the optimal time for the application of weed-killers or of mechanical treatments in the field.

Reference to Fig. 1 suggests that temporary reductions in the rate of growth of Cape tulip occur prior to stem initiation and at flowering, that is, that three cycles of growth are represented in the curve. To test the significance of these apparent reductions in the rate of growth, the yield figures have been subjected to statistical analysis and the curve of the relative growth rate studied. Actually, the fall in rate is not significant at either point although the observed reduction between the second and third harvests approaches significance. The available material was too variable to allow the establishment of small differences. It must be concluded that environmental conditions within the glass-house have influenced the results to some extent at least.

(b) Manurial Series.

The yields of Cape tulip and Wimmera ryegrass and figures showing their water requirements under sixteen manurial treatments are shown in Table 2.

Reference to Table 2 shows that, when grown in these sand cultures, Wimmera ryegrass did not respond in yield to dressings of phosphorus alone, but did to nitrogen, and gave a significantly greater response to

TABLE 2.—THE DRY MATTER PRODUCTION AND TRANSPIRATION RATIOS OF WIMMERA RYEGRASS AND CAPE TULIP WITH ADDED PHOSPHORUS AND NITROGEN. YIELDS IN GRAMMES PER POT.

Treatment.	Wimmera Ryegrass.		Cape Tulip.		
	Mean Yield.	Transpiration Ratio.	Mean Yield.	Mean Seed Yield per Plant.	Transpiration Ratio.
1. Nil	5·85	446	3·71	0·20	313
2. P_1 (KH_2PO_4 0·5 gm.) ..	7·85	379	2·75	0·17	239
3. P_2 (KH_2PO_4 1·0 gm.) ..	8·17	376	3·22	0·25	295
4. P_3 (KH_2PO_4 1·5 gm.) ..	6·44	433	3·41	0·20	332
5. N_1 ($NaNO_3$ 0·5 gm.) ..	12·88	495	3·66	0·32	377
6. N_2 ($NaNO_3$ 1·0 gm.) ..	15·89	435	5·33	0·46	435
7. N_3 ($NaNO_3$ 1·5 gm.) ..	17·66	421	3·75	0·32	392
8. P_1 N_1	20·28	369	3·72	0·24	330
9. P_2 N_1	24·41	336	4·21	0·32	468
10. P_3 N_1	23·02	366	4·80	0·37	330
11. P_1 N_2	29·81	367	5·61	0·47	380
12. P_2 N_2	27·54	363	5·77	0·45	388
13. P_3 N_2	29·01	348	5·53	0·53	443
14. P_1 N_3	34·36	332	5·00	0·40	332
15. P_2 N_3	34·36	308	5·69	0·45	321
16. P_3 N_3	31·60	346	5·34	0·51	353
General Mean	20·57	383	4·47	0·35	359
Standard Error	1·07	24	0·75	0·10	49
Standard Error—% ..	5·2	6·3	16·7	28·0	13·6

1.5 gm. $NaNO_3$ per pot than to 0.5 gm. The addition of phosphorus to N_1 (0.5 gm. $NaNO_3$ per pot) doubled the yield from N_1 alone, but no difference was found between one, two, and three levels of KH_2PO_4 with N_1. The yield increased with increasing amounts of nitrogen in the presence of phosphorus. 0.5 gm. KH_2PO_4 per pot represented an adequate amount of phosphorus in every instance. The F test showed the interaction P x N to be significant at the 1 per cent. point. Cape tulip did not respond to added nutrients, and nutrients had no real effect on the contributions to total dry weight of the component parts of the plant. The figures for seed production per plant under the various treatments are given in Table 2. No significant effect is shown, but the results strongly suggest increased seed production with increasing phosphorus and nitrogen. The variability of the material was very high. The average weight of the nutrient series plants was only 61 per cent. of that of the life history series plants at maturity. This may be accounted for in part by the ten days later date of planting and by the use in the manurial series of somewhat smaller corms. The mean flowering date of Cape tulip was the 18th September and of Wimmera ryegrass the 14th October.

The transpiration ratios for both species under the sixteen manurial treatments applied are given in Table 2. The reductions in the ratio in Wimmera ryegrass with one and two increments of phosphorus were almost significant but not those with three increments of phosphorus or with nitrogen alone. Where phosphorus and nitrogen were presented together, a definite reduction in water requirement was always obtained with Wimmera ryegrass. There was no significant interaction effect. The manures had no significant effect on the transpiration ratio of

Cape tulip. The decided variability of the Cape tulip material possibly was responsible again for the absence of significant differences in the results.

4. Discussion.

The results of the life history study suggest that there are three main periods of growth represented in the Cape tulip growth curve—one occupying the eight weeks after planting when the production of leaf and roots occurs at the expense of reserves; a second when photosynthesis and mineral uptake become effective, terminating six or seven weeks later at flowering, and a third period of rapid dry matter accumulation when the organization of stem, seed, and new corms proceeds. This third period occupies eight or nine weeks and is completed at maturity. The loss in weight of the original corm is continuous and eventually complete, and both leaf and roots tend to lose weight after flowering.

From the weed-control point of view, the interesting point in the curve occurs at flowering, when the old corms are almost depleted of food reserves, the new corms are just forming, and leaf production has reached its maximum. Control measures, involving the use of weed-killers already known to be capable of destroying the subaerial growth of Cape tulip or of mechanical methods such as ploughing or mowing, should be found most effective when applied at this time.

The lack of response by Cape tulip to added manures is also of interest. It is shown that Wimmera ryegrass under similar conditions responds to added phosphorus and nitrogen, both in terms of dry matter yield and in moisture economy. Wimmera ryegrass, with its satisfactory winter growth and erect smothering habit in early spring, is one of the most promising competing plants for use in the control of Cape tulip at Clare. It is felt that as the soil fertility level rises, aided by applications of superphosphate and by systematic grazing, a progressively greater measure of control of Cape tulip may be anticipated by the increasingly vigorous growth of sown pasture species in competition with the weed.

5. Acknowledgments.

The author's thanks are due particularly to Mr. J. A. Bull, who was responsible for the routine technical work carried out in the glasshouse, and to Miss F. E. Allan for advice concerning the statistical analysis of the results.

The Cultivation and Preparation of Flax.

For some time past the Council has been looking into the possibilities of work on fibres. In 1936 a report on that matter was prepared by Drs. A. E. V. Richardson and B. T. Dickson. This report, which has now been printed as a Parliamentary Paper (No. 64—F.3397—1937, Government Printer, Canberra), contained a recommendation that a Fibre Section be set up by the Council jointly between the Divisions of Forest Products and of Plant Industry. It is also pointed out that while Australian efforts to develop a flax industry had been disappointing, further investigation and experiment appeared to be justified. Subsequently some funds were made available to the Council and a small programme of experimental work on the retting of flax is now in hand. Knowing of this proposed work, the Secretary of the Council, Mr. G. Lightfoot, whilst he was in England last year, arranged with the Imperial Institute that it would prepare a report on the cultivation and preparation of flax fibre. That report has now been received and appears below.—Ed.

Flax can be grown on a variety of soils, and in general it may be stated that any soil on which good crops of oats or wheat can be raised would be capable of growing flax. A medium loam is considered the best; light sandy soil is unsuitable, as the crop will not withstand drought, and a soil that is too heavy is likely to produce a straw with low fibre content. Flax flourishes best in a temperate, humid climate without extremes of drought or excessive rainfall. It seems to find ideal conditions in such countries as Belgium, Northern France, and the British Isles, where in its growing season the nights are cool and moist and the days warm and showery.

Rotation.—Various systems of rotation are advocated and practised in different countries. These depend upon local conditions, and it is not possible to recommend any particular rotation as being the best. In general it is recommended that flax should not be grown on the same land more than once in at least five years, though, according to the United Kingdom Ministry of Agriculture and Fisheries, it is a common custom to take two successive crops of flax after clover ley, and if the land is sufficiently clean the second crop is often better than the first. In Belgium, flax generally follows oats, and in Ireland it is commonly sown after wheat.

Preparation of Land.—Flax is a quick growing crop, the growing period extending only over some ten weeks, and the best conditions of soil are those which allow this growth to take place without interruption. Land intended for flax sowing should be ploughed early, well broken up, and before sowing it should be given a fine tilth and the surface made even. The subsoil should be compact.

Manuring.—Experience would seem to show that not very much in the way of fertilizers is necessary, and in any case attempts to grow flax on poor land heavily fertilized are not recommended. The Ministry of Agriculture suggests for this country superphosphate at the rate of 2 cwt. to the acre, applied at the time of sowing, perhaps supplemented by a dressing of 1½ cwt. of muriate of potash and not more than ½ cwt. of sulphate of ammonia. With regard to this last, however, it is probably safest not to use any nitrogen fertilizer unless the soil is known to be deficient in that element, as such fertilizers tend to make the fibre coarse and weak, increasing the weight of straw without improving the yield of fibre.

Experiments conducted by the Linen Industry Research Association have shown that potash, if not in excess, causes an increase in length of the straw, and, if the expense is not too great, it is thought that the usual rate of 1½ cwt. of muriate of potash per acre might, with advantage, be increased to 2½ or to 3 cwt. per acre. The results with superphosphate indicated that this material produced a marked improvement in the percentage of fibre, and to obtain the best possible results it is suggested that a dressing of say 5 cwt. per acre should be used, in conjunction with 2 cwt. of muriate of potash (L.I.R.A., Research Institute Memoir No. 27).

Lime may be used if the soil is acid; it should not be applied, however, just before sowing the flax, but before some previous crop, preferably two or three years beforehand. Excess of lime is to be avoided, as it tends to reduce both the yield and the strength of the fibre.

When fertilizers are applied it is important that they should be distributed uniformly. Otherwise, the crop is likely to be uneven in height, and it is particularly desirable in the case of flax that length of stem should be as uniform as possible.

Varieties of Seed.—A large amount of work has been carried out in the production of different strains of flax, a matter to which the Linen Industry Research Association of Lambeg, Northern Ireland, has given much attention. The "J.W.S." variety gives a large yield per acre, but produces a fibre of only medium quality. It is now largely supplanted by Liral and Stormont pedigree flaxes which give a higher proportion of fibre to straw than "J.W.S." Leading varieties are Liral Monarch, Liral Crown, Liral Dominion, Stormont Gossamer, and Stormont Cirrus. Information regarding these varieties and their particular characters and merits is given in Leaflet No. 1 (Revised 1938) entitled "Flax Seed, 1938." issued by the Ministry of Agriculture, Northern Ireland.

Questions as to which varieties can best be recommended for growing in particular districts of Australia must necessarily be decided by trials conducted locally. It is understood that pedigree seed has already been obtained from the Linen Industry Research Association for purposes of trial.

Sowing.—The usual method of sowing is broadcasting, by hand or otherwise, but drillers can be used, the rows being drilled about 3 inches apart. The seed should be sown from ½ inch to 1 inch deep; uniformity of depth is important. It is advantageous for the seed to be sown as early as possible; in Great Britain sowing is recommended as soon as the risk of severe frost has passed.

The amount of seed to be sown per acre depends on the percentage germination of the seed, which should have been previously determined. With seed germinating 90 to 98 per cent., a standard rate of sowing would be 100 to 90 lb. to the acre, though higher rates may be used on suitable land. Proportionally higher quantities would be required with seed of lower germination. Generally speaking, seed of lower germination than 80 per cent. should not be sown.

After sowing, care must be taken to keep the crop free from weeds, and this should be attended to early, when the crop is only a few inches high.

Yield.—The yield of fibre per acre varies with the variety of seed, the rate of sowing, soil, and other conditions. The closer the sowing (compatible with adequate nourishment for the plant) the finer the fibre and (up to a point) the greater the yield. In Ireland, where sowing is generally at the rate of about 90 lb. of seed to the acre, yields of about 4 cwt. of fibre to the acre are usual. In Belgium and Northern France, sowing at rates up to 150 lb. to the acre is common, and yields up to 6 cwt. per acre are obtained.

Harvesting.—The precise stage at which to harvest flax is a matter that calls for some judgment. The plants should not be allowed to become fully ripe but should be pulled when the green colour of the lower part of the stem has changed to yellow up to about one-third of its height, at which stage the older seed capsules will contain seed that is just beginning to turn brown. Harvesting at this stage does not prevent the seed being saved if required, as it continues to ripen on the plants after pulling. Harvesting should be done in dry weather and should be completed as quickly as possible.

Pulling is still largely done by hand, but there are now flax pulling machines, and these would doubtless be used in Australia. The Boby-Soenens machine is in extensive use, especially in Belgium, and particulars of this machine, supplied by Messrs. Robert Boby, of Bury St. Edmunds, are sent herewith. This machine is described as doing the work of about 30 persons, being capable of pulling from 5 to 6 acres of flax per day. It weighs about 19 cwt. and is worked by two horses or by a tractor. Amongst the other advantages claimed for the machine is that the flax is gathered free from weeds.

There has recently come to the fore in Belgium a new light flax pulling machine invented by M. Maurice Soenens. This is made entirely of steel and weighs about 300 kilos (say 6 cwt.); it is carried by two pneumatic tires, and can be hauled by a single horse, the stem-pulling device being driven by a 3 horse-power internal combustion engine. A specification of M. Soenen's invention, supplied by MM. J. Bede et Cie, a firm of patent agents in Brussels, is enclosed, together with two photographs of the machine.

Messrs. Boby were asked for observations regarding this machine, and a copy of their letter, dated 23rd December, 1937, on the subject is attached. It is of course to be assumed that Messrs. Boby's views may not be entirely unbiased, and the new machine would appear, by reason of its lightness, to offer definite advantages over the Boby-Soenens machine which weighs about 19 cwt. and requires either two horses or a tractor to work it. However, under conditions of large scale production in Australia, it may perhaps be considered that the heavier machine, drawn by a tractor, is preferable.

Treatment after Harvesting.—The treatment of the crop after pulling depends upon conditions and practice in different countries and upon whether it is desired to recover the seed. In Belgium the crop is left in the open air to dry thoroughly before being stacked. The seed matures on the plant and is afterwards recovered. In Ireland the seed

is not saved, and the processes of fibre extraction can therefore be started at once. The seed bolls are removed by "rippling," that is by drawing the heads through a coarse comb. Particulars of up-to-date flax de-seeding machines, supplied by Messrs. Robert Boby Ltd., capable of dealing with 8 to 12 tons of flax straw per day of ten hours, are enclosed.

Retting.—The retting of flax, that is the steeping in water and consequent separation of the fibres from the woody portions by the dissolution, through bacterial action, of the pectic material connecting them, is effected in various ways. In Belgium, retting in the River Lys has in the past been almost the basis of the flax industry, this river offering conditions that are particularly favorable to successful retting. In Ireland, pond retting is common. Another method, known as dew retting, consists simply in spreading the flax on the land and exposing it to the action of the weather. This method is employed in Russia, and to some extent in Belgium and in Brittany, and is understood to have been practised in Australia. It is the least efficient of all methods.

In recent years it has been increasingly the practice to ret in tanks of warm water. These are commonly of concrete, and the treatment consists in immersing the bundles of flax in the water which is kept at a raised temperature. The process does not differ in any fundamental principle from other forms of water retting, but it can be kept under control by regulating the temperature and the circulation of the water in the tanks, thus producing the optimum conditions for bacterial action and making uniformity of product more certain. The rate of retting in general increases with temperature. At about 35°-37°C., retting is most rapid, but there are drawbacks to the higher temperatures, and the process is more usually carried out at a maximum of 30°-32°C., and frequently at 26°-28°C. The most suitable conditions for Australia could best be determined by practical trials.

The Linen Industry Research Association has carried out systematic trials in tank retting in Northern Ireland and has succeeded, under carefully controlled conditions, in reducing the retting period to three days. In addition to the saving in time effected by warm water retting, the method has the advantage that it can be carried out at any time of the year.

The tank system naturally involves a considerable amount of labour in handling the straw. To reduce this as much as possible, in experiments conducted in Norfolk, a row of stitches was put into the flax whilst in mat form. Such a mat can be easily rolled up and handled in the tank, whilst the operation of drying after retting is particularly facilitated, as the flax is merely unrolled against a wire in the field and left to dry.

The high quality of the best Courtrai flax is attributed in part to the fact that it is retted twice with a short interval between the two rettings. In order to reproduce these conditions in tank retting, the Linen Industry Research Association has devised a system of duplex retting, which does away with the labour of removing the straw between the rettings. The method is covered by British Patent No. 449,108 and uses a tank arrangement covered by an earlier Patent, No. 407,773. Copies of these specifications are attached. The tanks are arranged in pairs, and one batch is receiving a second ret whilst the other is in the

first stage. Each batch has a leach in warm water for about four hours, a ret of about three days in warm water, a wash in cold water, a second ret of three days in warm water, and a final wash in cold water. The flax in the first ret is treated with water containing bacteria from other flax undergoing a second ret.

In another system, known as the Cousinne process, the water in the retting tanks is changed twice a day. The tanks are half emptied in the morning and refilled with water at 25°C. and the temperature then raised to 30°C. The same process is repeated in the evening.

In ordinary retting and most tank systems, the bacteria which bring about the disintegration of the tissue are anaerobic and are present naturally on the flax straw. In a process devised by Rossi, use is made of an aerobic bacterium (*Bacillus comesii*). His process is described fully in an article entitled "Industrial Retting of Textile Plants by Microbiological Action," published in the *International Review of Agriculture,* 7, (8): 1067-75, 1916. Briefly, the straw is immersed in tanks of water maintained at a temperature between 28°-30°C., to which has been added a quantity of pure culture of *B. comesii.* An air current is passed through the mass of straw during the whole period of retting, and the rate of the current must be so adjusted that the growth of anaerobic bacteria is inhibited. When the process is properly controlled, the danger of over-retting is almost entirely avoided, whilst the effluents are much less obnoxious than in the case of anaerobic retting.

A modification of the warm-water system of retting is the Schneider channel process, which has been tried in Germany. The apparatus is so arranged that the straw moves slowly through channels against a counter-stream of warm water, the whole process of retting being continuous. Although, in theory, this method has certain advantages, it has not proved successful in practice, since the channels eventually become seriously contaminated with undesirable organisms, and proper control of the degree of retting is almost impossible. A survey and critique of the various retting systems will be found in Ruschmann's book and article referred to in the bibliography.

Further information regarding retting is contained in the typed notes entitled "The Art of Retting" and "Modern Patent Flax Retteries" which have been furnished by Messrs. Fairbairn Lawson Combe Barbour Ltd., of Leeds and Belfast, and which are enclosed herewith.

The possibility of separating the fibre from the stems by some method that would dispense altogether with bacterial retting has long been the subject of investigation, and numerous processes have been devised and patented. So far, however, none of these processes has been developed on a commercial scale. In one case, a company with a nominal capital of £1,000,000 was formed to work the process, and several thousand acres of flax were grown in Yorkshire under contract with the company, but the venture failed and the company was subsequently wound up.

The processes fall roughly into two categories, mechanical and chemical; in some of the latter the straw is given a preliminary mechanical treatment also. The disadvantage of chemical treatment

is that the fibre is liable to be adversely affected from the point of view of ordinary flax. For this reason a number of the processes take the treatment beyond that required to yield a product comparable with retted flax, and disintegrate the material into its ultimate fibres which can be spun in admixture with cotton.

Among the chemical processes, reference may be made to the Tergan process. This process, which consists of the chemical treatment of "decorticated" unretted straw, has been developed by the Linen Industry Research Association. No details of the process appear to have been published, but, according to the Report of the Department of Scientific and Industrial Research for 1933-34, the results of numerous experiments were regarded as very satisfactory, although it was not possible then to say anything definite as to the costs of the process in full-scale operation. At the annual meeting of the Linen Industry Research Association held on 17th December, 1936, the Director of Research stated that a machine had been built to handle decorticated flax through the chemical treatment, but the most suitable methods of handling the flax after the treatment had not then been settled.

Of other chemical processes, it will be sufficient just to mention the names of some of the more prominent which have been devised in recent years. They are the Pritchard, Michotte, Watson-Waddell, Waentig, F.E.S. (Franklin E. Smith), and Windrum. The last three are "cottonising" processes. Great difficulties appear to have been met with in devising a purely mechanical method of preparing spinnable fibre from flax straw. One which seems promising is that worked out at the Linen Industry Research Association and described in the accompanying Patent Specifications (B.P. 439, 741, and 461,712). The Association is pursuing its investigations into this question, including the devising of a more efficient scutcher for dealing with the fibre produced, and, although the trials hitherto carried out have shown great promise, it is too early yet to express an opinion as to whether the method will eventually supplant the ordinary retting process.

As mentioned in the accompanying typed note on "Modern Patent Flax Retteries," tunnel driers are now largely used for drying the retted fibre. According to a note in the *Irish Textile Journal* for January, 1938, during the past year 30 German flax and hemp retteries are said to have been equipped with tunnel driers working with a fibre temperature of 35°–40°C., and a drying time of 25 minutes. The process is worked in such a manner that it simulates natural drying, the moisture from the retted straw being removed at a low temperature by large quantities of air.

Scutching.—The process of scutching, that is, the removal of the woody portion from the fibre, is now largely mechanized. Particulars of scutching machines offered by Messrs. Boby are enclosed. Illustrations are also sent of equipment for the same purpose made by Messrs. Fairbairn Lawson Combe Barbour Limited, of Leeds and Belfast, consisting of a flax straw breaker and a scutching handle. This latter firm have informed the Imperial Institute that their representative in Australia is Mr. H. D. Sinclair, Australia House, Carrington-street, Wynyard Square, Sydney, New South Wales, to whom requests for information regarding their plant may be addressed. Messrs. Fairbairn Lawson Combe Barbour Limited are primarily textile machinists,

supplying machinery for dealing with the flax fibre after it has been prepared, and their catalogue of such machinery is enclosed in case it may be of interest.

Diseases.—It is perhaps unnecessary to deal in any detail with the question of diseases, as consultation with the Imperial Mycological Institute would seem to be indicated if it is found necessary to go into the matter fully in relation to flax cultivation in Australia. Here it may be sufficient to say that flax diseases for the most part are seed-borne, and in such cases they are in general combated by planting disease-resistant varieties or by disinfection of the seed before sowing. The subject has received considerable attention, and since most, if not all, of the modern varieties are resistant, the question of diseases is not as a rule a serious one; indeed, in Ireland to-day the flax crop is regarded as being almost free from any serious disease. Nevertheless, in a new country careful watch would have to be taken to ensure that no disease takes on an epidemic character.

Among the principal diseases of flax may be mentioned wilt (*Fusarium lini*), rust (*Melampsora lini*), seedling blight or canker (*Colletotrichum lini*), browning and stem-break (*Polyspora lini*), and pasmo or rust blotch (*Phlyctaena linicola*).

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Downy Mildew (Blue Mould) of Tobacco: Its Control by Benzol and other Vapours in Covered Seedbeds. IV.

By J. M. Allan, B.Agr.Sc., M.D.A., A. V. Hill, M.Agr.Sc.,† and H. R. Angell, Ph.D.‡*

Summary.

1. Three seasons' experiments and the experience of growers in all the States of the Commonwealth have shown that downy mildew of tobacco seedlings can be economically controlled by benzol, an evaporation surface ratio of 1 square inch of benzol to 100 square inches of seedbed usually being sufficient. In comparative tests, other hydrocarbons were always less satisfactory than benzol.

2. More effective control is obtained with many than with few centres of evaporation. In districts where the disease is seldom destructive it may be unnecessary to use benzol every night.

3. Under the conditions of our experiments, calico seedbed covers properly cared for and treated with suitable fungicides are serviceable for three or more years. Poor quality calico may not retain sufficient vapour for prevention of the disease.

1. Introduction.

During the past season, practically all tobacco seedlings transplanted in South Australia and Western Australia, a high percentage in New South Wales, and about 38 per cent. in Victoria were protected from downy mildew by benzol vapour. In Queensland and Tasmania, the disease was less destructive, and therefore, fewer growers used benzol. The certainty of obtaining healthy seedlings, the convenience of being able to raise them on the farm instead of in remote districts, and the low cost per thousand transplanted, are features of the vapour beds that led to their relatively rapid adoption by growers.

The experiments made by us and by the State Departments of Agriculture in the main tobacco growing areas have shown that disease-free seedlings can be produced with certainty, even where the environmental conditions are conducive to general destruction of seedlings in open seedbeds.

The work reported in this paper confirms the results obtained at Eurobin, Victoria, during the two previous seasons, and indicates that some modifications of the general procedure given in previous papers§ may result in the production of disease-free seedlings at lower cost.

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2. Experiments and Results.

Fifteen seedbeds, each measuring 25 by 4 feet, and six, each measuring 20 by $6\frac{1}{2}$ feet, as previously described, were again used. Each of the latter was divided into two parts of equal area. With the exception of two, that were each subdivided into four sections and sown with seed of the varieties Hickory Pryor, Conqueror, Dungowan, and Dungowan Selection, all the beds were sown with Dungowan on the 25th August. One of the aims in the management of the seedbeds was the production of seedlings that would make satisfactory transplants even though set out under adverse conditions. Transplanting was begun on 22nd October, and seedlings fit for that purpose were taken from the beds over a period of six weeks. Up to 15th November, the average number of transplants removed from each square yard of seedbed was 660. Many seedlings were transplanted after that date.

The untreated control was situated about 100 yards distant from the others. Adjoining the latter were farmers' seedbeds in which benzol was not used until after the disease occurred; therefore, they also served as controls. On 9th October, an outbreak of downy mildew occurred approximately 1 mile away, four days later in the beds adjoining ours, and on the 27th in the control bed, which was then destroyed.

Because the required hydrocarbons were not then available, treatment with benzol was begun on 9th October in all beds, except the control; four days later, the various hydrocarbons were substituted, and used until 1st December. Unevaporated residues were returned each morning to the bulk supplies.

Seedbed covers were of medium quality, unbleached calico, 60–65 threads per inch, and excluding those used as controls, were treated with various preservatives. The seedlings were uncovered for approximately ten hours each day, except during 62 hours of wet weather in late October, when excess water was excluded by covering continuously. In two of the smaller seedbeds, the covers were removed for only six hours per day.

Because nearly all the seedbeds remained relatively or altogether free from disease until comparatively late in the season, they were inoculated with conidia of the downy mildew organism (*Peronospora tabacina* Adam) on 22nd–24th November, the final observations on the occurrence of the disease being made on 6th December, five days after the use of hydrocarbons and seedbed covers was discontinued.

The experimental data are summarized in Table 1.

(i) *Comparative Tests of Efficiency of Hydrocarbons.*—Comparative tests with benzol, toluol, and X3 solvent were made at evaporation surface ratios of 1/72, 1/100, and 1/144, and X300 special boiling point spirit at 1/72 and 1/36. The hydrocarbons were placed each evening in ten shallow cans of suitable size, spaced along the middle of each bed (25 by 4 feet).

Downy mildew was observed on 12th November on a small group of seedlings in the seedbed in which benzol was used at the 1/144 ratio, but the plants were not badly affected and the disease did not spread during

TABLE 1.—SUMMARY OF DATA—EUROBIN EXPERIMENTS, 1937.

Seedbeds sown: 25th August.
Treatment commenced: 13th October.
Treatment concluded: 1st December.
Transplanting commenced: 22nd October.
Seedling inoculated: 22nd–24th November.
Seedbed measurements: Nos. 1 to 15—25 by 4 feet; Nos. 16 to 27—20 by 3¼ feet.
Last observations were made on 6th December, five days after benzol was discontinued.

Seed-bed Number.	Fungicide.	Evaporation Ratio.	Number of Centres of Evaporation.	Rate of Evaporation. Gallons per Day per 100 sq. ft.	Remarks.
1	Benzol	$\frac{1}{72}$	10	·29	A few diseased plants in Hickory Pryor and Conqueror varieties, and none in Dungowan five days after treatment discontinued
2	Benzol	$\frac{1}{100}$	10	·21	A few diseased plants nine days after inoculation
3	Benzol	$\frac{1}{144}$	10	·17	Disease present 12th November and widespread 1st December
4	Toluol	$\frac{1}{72}$	10	·18	Similar to 2
5	Toluol	$\frac{1}{100}$	10	·13	Similar to 2
6	Toluol	$\frac{1}{144}$	10	·12	Disease seen nine days after inoculation, worse than 3
7	X300	$\frac{1}{36}$	10	·08	Disease widespread 12th November and bed dug in
8	X300	$\frac{1}{72}$	10	·05	Disease widespread seven days after inoculation. Plants dying 6th December
9	X3	$\frac{1}{72}$	10	·23	Disease along seedbed edges nine days after inoculation and subsequently, worse than 3
10	X3	$\frac{1}{100}$	10	·16	Slightly worse than 9
11	X3	$\frac{1}{144}$	10	·14	Slightly worse than 10
12	Benzol	$\frac{1}{100}$	3	·19	Disease to within 18 inches of cans nine days after inoculation and subsequently, similar to 10
13	Benzol	$\frac{1}{100}$	5	·20	Disease on few plants 15th November, but later less than in 12
14	Benzol	$\frac{1}{100}$	7	·21	Similar to 9
15	None	..	..	..	Disease widespread 27th October and bed dug in
16	Benzol	$\frac{1}{72}$	6 filled every alternate night	·16	Disease widespread five days after treatment discontinued
17	Benzol	$\frac{1}{100}$	6 filled every alternate night	·12	Disease observed nine days after inoculation and later widespread
18	Benzol	$\frac{1}{144}$		·08	Disease observed seven days after inoculation and later, worse than 17

TABLE 1—*continued.*

Seed-bed Number.	Fungicide.	Evaporation Ratio.	Number of Centres of Evaporation.	Rate of Evaporation Gallons per Day per 100 sq. ft.	Remarks.
19	Benzol	$\frac{1}{72}$	Trough	·41	No downy mildew
20	Benzol	$\frac{1}{100}$	Trough	·34	Similar to 17
21	Benzol	$\frac{1}{144}$	Trough	·23	Similar to 16
22	Benzol	$\frac{1}{72}$	6 filled 4 p.m., emptied 10 a.m.	·33	No downy mildew
23	Benzol	$\frac{1}{100}$		·29	Similar to 20
24	Benzol	$\frac{1}{100}$	6	·23	A few diseased plants five days after treatment discontinued
25	Benzol	$\frac{1}{100}$	6	·26	A few diseased plants five days after treatment discontinued
26	Benzol	$\frac{1}{100}$	6	·26	Similar to 20
27	Benzol	$\frac{1}{100}$	6	·22	Hessian seedbed-cover. Disease observed 4th November, became widespread, and bed dug in on 12th November

the following two weeks. On the same day, it was found throughout the seedbed treated with X300 special boiling point spirit at the 1/36 ratio. This bed was then destroyed. On 29th November, the remaining seedbed treated with X300 special boiling point spirit was severely affected. Nine days after artificial inoculation, the disease was observed in all seedbeds, other than that in which benzol was used at the 1/72 ratio, the diseased seedlings, except those in the seedbed treated with X300 special boiling point spirit being confined to the outer 6 to 9 inches of the seedbeds. The least number of affected plants was in the seedbeds treated with benzol at 1/100 and toluol at 1/72 and 1/100. When examined on 6th December, five days after the use of hydrocarbons was discontinued and fourteen days after artificial inoculation, a few diseased plants were found in the seedbeds in which benzol and toluol were used at the 1/100 and 1/72 ratios. All other seedbeds were thoroughly diseased. Of the four varieties in the beds in which benzol was used at the 1/72 and 1/100 ratios, only Hickory Pryor and Conqueror seedlings were affected.

(ii) *Relation of Number of Centres of Evaporation of Benzol to Occurrence of the Disease.*—In three seedbeds, each measuring 25 by 4 feet, an evaporation surface ratio of 1/100 of benzol was provided by three, five, and seven cans respectively. On 15th November, downy mildew was observed on a few seedlings at one end of the seedbed with five cans, but it did not spread during the following two weeks. During a general examination on 1st December, diseased plants were found along the sides and ends of those in which seven and five cans, respectively, were used, and up to within 18 inches of the cans in the bed provided with three. All three seedbeds were more generally affected than a comparable bed with the same ratio of evaporation surface of benzol from ten cans.

(iii) *Use of Benzol on Alternate Nights.*—At ratios of 1/72, 1/100, and 1/144, respectively, from six cans, benzol was used in three of the smaller beds every alternate night. The seedlings remained healthy until 28th November, six days after artificial inoculation, when downy mildew was observed on isolated plants in the bed with the 1/144 ratio. A few days later the seedlings in both this and the bed with the 1/100 ratio were severely diseased; those in the remaining bed were apparently healthy. On 6th December, five days after benzol was last used, the disease in all three beds was more widespread than in several similar beds treated with benzol every night at an evaporation surface ratio of 1/100.

(iv) *Use of Benzol in Troughs.*—In this experiment evaporation surface ratios of 1/72, 1/100, and 1/144 were provided from single troughs the same length as the seedbeds (20 feet). On 1st December, the disease was observed in the seedbed in which the 1/100 ratio was used, and five days later was widespread in this and in the one in which the 1/144 ratio was used. The seedlings in the remaining bed were apparently healthy.

(v) *Other Experiments.*—The covers of two seedbeds (each 20 by 3¼ feet) in which benzol was used at ratios of 1/72 and 1/100, respectively, in six cans, were removed for only six hours each day. On 1st and 6th December, the disease was observed on a few plants in the seedbed with the lower concentration of vapour; the seedlings in the other bed were unaffected.

In two of the smaller seedbeds, in which benzol was used at the 1/100 ratio, the disease was first observed on 6th December, comparatively few plants being affected.

In a comparative test of the efficiency of calico and 14-oz. hessian as cover materials, the disease was observed in the hessian-covered seedbed on 4th November, but the other remained healthy until 1st December. In the hessian-covered seedbed, the disease was due to natural infection; it became so widespread that the seedlings were useless for transplanting and were consequently destroyed.

(vi) *Seedbed Cover Dressings.*—Shirlan AG and Shirlan WS plus Agral 2* were used on eight and seven seedbed covers, respectively. Covers treated in 1936 and again in 1937 with each of these dressings, and one untreated control, were again used. Others were treated with napthenic acid†, copper emulsion‡, cupra-ammonium§, and khaki‖. New untreated calico was also used.

At the conclusion of the experiments, the untreated calico used for the second season was stippled by fungal growth; nevertheless it appeared to be sound enough for use for another season. The calico treated with Shirlan for the previous season's test was less discoloured than the untreated cloth of the current season, being somewhat similar in this respect to the one treated with napthenic acid or copper emulsion. Shirlan and khaki-treated covers were slightly affected, the latter also being stained brown by the dressing. The cupra-ammonium dressing prevented fungal discoloration.

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* This *Journal* **10**: 4, 1937.

† Napthenic acid one part, petrol two parts—brush on to cloth.

‡ Cloth dipped in copper emulsion. See *Queensland Agr. J.* **40**: 470–494, 1933.

§ A 5 per cent. solution by weight of copper sulphate in water, and strong ammonia added until precipitate forms and redissolves. The cloth was dipped.

‖ Chrome alum ½ lb., ferrous sulphate ½ lb., pyrolignite of iron ½ lb., water 2 gallons. Soak cloth in mixture then transfer to a solution of sodium silicate 1½ lb. in water 2 gallons.

3. Discussion.

In our experiments during the past three years, benzol has consistently given better control of downy mildew than other hydrocarbons. Toluol or X3 solvent may be used as substitutes, but sometimes cause seedling injury. During this season, X3 solvent in beds covered continuously for 62 hours killed all seedlings in the seedbed with an evaporation surface ratio of 1/72. Healthy seedlings were pricked out into the bed, and some were removed three weeks later for transplanting. Those remaining were severely injured by the usual nightly treatment. X300 special boiling point spirit gave unsatisfactory control even at an evaporation surface ratio of 1/36.

The amounts of hydrocarbons lost by evaporation tended to be greater than in the previous season, presumably due, in part, to higher mean temperatures. In both seasons the amount evaporated was not directly proportional to the area of evaporation surface, for if the latter was increased by 100 per cent. the quantity lost by evaporation was usually increased by little more than 50 per cent. The relatively greater rate of evaporation of benzol in the narrower seedbeds probably accounted for the somewhat better control obtained therein.

According to the results of these experiments, the number of centres of evaporation is one of the factors that determines the degree of control of the disease obtained by benzol vapour. Usually, the seedlings most distant from the cans are attacked first, and this may, in part, account for the somewhat better results obtained in the narrower beds. Benzol is equally effective in disease control whether it is evaporated from a trough or from cans, but less is used in the latter.

The evaporation surface of benzol necessary for the complete protection of seedlings after artificial inoculation with a heavy spore load is 1/72 of the seedbed area. However, if the disease occurs as a result of infection from natural sources, our experiments in the north-east districts of Victoria indicate that, provided the seedbed construction, cover material, and general management are satisfactory, a ratio of 1/100 is sufficient under average conditions. If conditions are very favourable for the disease, an evaporation surface ratio of 1/72 may be necessary. During last season the disease occurred in some farmers' seedbeds before the use of benzol was begun or if insufficient was used. The 1/72 ratio applied continuously for three days and nights, followed by the 1/100 ratio at night only, prevents further spread and appears to eliminate the disease. However, some of the seedlings apparently remain infected, the disease appearing subsequent to transplanting.

At evaporation surface ratios of 1/100 or 1/144 on alternate nights, the disease occurred after inoculation and was not effectively controlled, but at the 1/72 ratio it was prevented. In the latter, however, it was widespread a few days after the use of benzol was discontinued, and, therefore, it appeared that the plants were infected but the disease was not obvious. The use of benzol on alternate nights has given satisfactory results in two seasons at the Tobacco Experiment Farm, Ashford, New South Wales*, and in parts of Queensland†, but further experiments appear to be desirable to determine if this procedure may be safely employed.

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* Reported in correspondence from Mr. C. J. Tregenna, Tobacco Expert, Department of Agriculture, N.S.W.

† Reported in correspondence from Mr. L. F. Mandelson, Research Officer, Department of Agriculture and Stock, Queensland.

Seedbed covers treated for the prevention of fungal discoloration and decay, and properly cared for, might reasonably be expected to last for three seasons. Although the rate of evaporation of benzol under hessian was similar to that under calico, insufficient vapour for disease control was retained by the former. Only control, not prevention, was obtained in some farmers' seedbeds in which calico of poor quality was used. Provision for easy manipulation of seedbed covers is of importance to the farmer. In the best arrangement seen during the season, the cover of a tent type seedbed was supported by a wire ridge and attached by rings to wires placed on either side, below the top of the seed bed frame. By releasing the side wires from suitable fasteners placed on the long sides of the bed, the cover could be gathered to one end, remaining supported above the ground.

4. Acknowledgments.

It is a pleasure again to acknowledge the co-operation of Messrs. Panlook Bros. Pty. Ltd., Eurobin, Victoria, on whose property the experiments were conducted.

Bunt Infection and Root Development in Wheat.

By F. W. Hely, B.Sc.Agr., F. E. Allan, M.A., Dip.Ed.,† and H. R. Angell, Ph.D.‡*

Summary.

There is a significant reduction in the root development of 8-week-old bunted wheat plants compared with others that are bunt-free.

Differences in stunting of wheat as a result of infection by *Tilletia tritici* (Bjerk.) Wint. and *Tilletia levis* Kühn were noted by Harwood (1) and by Potter and Coons (2). Selby (3) and McAlpine (4), however, did not observe the same effect under their conditions. Rodenhiser (5) reported that both organisms caused significant reduction in the length of wheat culms and that the relative amount of stunting produced by two races of *T. tritici* was greater than by *T. tritici* or by *T. levis.* Contrary to these observations that were made on developed plants, Churchward (6) reported that inoculation of seed of certain varieties of wheat with a physiologic form of *T. tritici* resulted in more vigorous growth of seedlings than the bunt-free controls. Flor, Gaines, and Smith (7) among other things found differences in the reaction of certain wheat varieties to various races of bunt and that the differences were influenced by environmental conditions.

We report in this paper the results of an experiment made to determine the effect of bunt on the development of the root system of wheat seedlings. Comparison may be made with those obtained with *Urocystis tritici* Koern (8). The general procedure in growing and harvesting the plants was the same as is there described. Nabawa, a variety that is regarded as susceptible under field conditions, was used. Graded seed was surface-sterilized, washed in tap water, and dried. This was used for the check series; for the inoculated one the grain was then given a medium spore load with a composite sample of spores of *T. tritici* and *T. levis* freshly obtained from Nabawa and a number of other common susceptible and resistant varieties. The grain was sown somewhat later than the optimum time for the district and variety; consequently, the average soil temperature during germination was lower than during the average sowing season, being in this instance 6.1°C. instead of 8.2°C. According to Faris (9), a soil temperature of 10°C. or lower during germination was associated later with a higher percentage of bunted heads than were higher temperatures.

Eight weeks after sowing the seed the plants were treated as already described (8) and the roots and tops weighed. The "t"-test showed that there was a significant depression in root weight due to inoculation and consequent infection with bunt. An apparent depression in the weight

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of the tops, however, was not significant. The following table gives the mean weights in grams of dry material per pot:—

Roots.		Tops.	
Inoculated.	Check.	Inoculated.	Check.
1·05	1·30	1·30	1·35

The values of "t" were 8.45 for the roots and 1.38 for the tops; the former of these is significant at the 1 per cent. level, but the other does not even reach the 5 per cent. level of significance.

Since, according to these results and others recorded elsewhere, the root system of wheat plants is significantly reduced by both bunt and flag-smut, it may be reasonable to conclude that smuts of related plants may have a similar effect. To what extent root-reduction may affect the final yield of grain and straw may be surmised. Work on this aspect of the problem may be undertaken when, and if, circumstances warrant it.

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The Effect of *Urocystis tritici* Koern. on the Extent of Development of the Roots and Aerial Parts of the Wheat Plant. II.

By H. R. Angell, Ph.D., F. E. Allan, M.A., Dip.Ed.,† and F. W. Hely, B.Sc.Agr.‡*

Summary.

Inoculation with flag-smut significantly reduced root growth of seedlings of Nabawa, Ford, and Federation wheat grown in cans out-of-doors. Simultaneously, there was a significant depression in the weight of the tops of all three varieties, but in the second experiment it was less marked in Nabawa than in the others.

In one experiment made in late summer, no significant difference was noted between the inoculated and the control plants, this being probably due to relatively high temperature conditions immediately after germination.

1. Introduction.

In an earlier paper§ the writers reported a reduction of the root system, and in some instances of the tops, of young plants of three varieties of wheat, resulting from infection by *Urocystis tritici* Koern. The experiments were repeated during the following season, the very susceptible variety Federation, the medium resistant Ford, and the highly resistant Nabawa being again used. Concurrent experiments with bunt are also reported elsewhere in this issue.

As before, one series was begun at the normal planting time in autumn, another rather late in the season, and, in addition, another was made in the late summer to observe the effect of relatively high average temperature during germination and a slowly failing temperature during the growing season.

2. Materials and Methods.

The general procedure followed was the same as already outlined§. Precautions were taken to eliminate, as far as possible, all factors likely to contribute to variation, other than the effect of the organism on the varieties being tested. Soil from the same lot was used, and the moisture content was maintained at approximately 50 per cent. of its holding capacity. The plants were gathered and prepared for weighing as before.

3. Results.

The data from these experiments were examined statistically by means of the analysis of variance, separate analyses being made for root weight and weight of tops in each experiment. The mean weights of inoculated and un-inoculated plants in each variety are given in Table 1.

In the first experiment, the analysis of variance of root weights showed that the effect of inoculation was significant, at the 1 per cent. level, in reducing root weight. The interaction of varieties and treatment was not significant, indicating that all the varieties reacted similarly to the inoculation. The variety term was significant at the 1 per

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§ Angell, H. R., Hely, F. W., and Allan, F. E.—The effect of *Urocystis tritici* Koern. on the extent of development of the roots and aerial parts of the wheat plant. I. This *Journal*, 10: 136-142, 1937.

cent. level, and examination of the mean root weights of the varieties, including both inoculated and un-inoculated plants, showed that the average root weight for Nabawa was significantly greater than for Federation and slightly, though not significantly, less than for Ford.

TABLE 1.—TABLE OF MEAN WEIGHTS OF ROOTS AND TOPS.

1st Experiment.

—	Ford Inoculated.	Ford not Inoculated.	Federation Inoculated.	Federation not Inoculated.	Nabawa Inoculated.	Nabawa not Inoculated.	Standard Error.
Weight of roots ..	1·167	1·351	1·078	1·237	1·163	1·286	± ·0216
Weight of tops ..	1·269	1·371	1·314	1·357	1·101	1·141	± ·0175

2nd Experiment.

—	Ford Inoculated.	Ford not Inoculated.	Federation Inoculated.	Federation not Inoculated.	Nabawa Inoculated.	Nabawa not Inoculated.	Standard Error.
Weight of roots ..	0·959	1·171	0·732	0·886	1·067	1·299	± ·065
Weight of tops ..	1·141	1·343	1·116	1·289	1·329	1·348	± ·025

The analysis of weights of tops in the first experiment showed significance at the 1 per cent. level for both variety and treatment terms. The average weight of tops for Nabawa was below those for Ford and Federation. In all three varieties the inoculation caused a depression in weight of tops.

In the second experiment, according to the analysis of variance of root weights, both variety and treatment differences were significant at the 1 per cent. level. The root weights of Nabawa and Ford were again greater than Federation, and in each variety, the inoculation caused a decrease in root weight. The effect of inoculation was the same for all varieties, the term in the analysis of variance for interaction of varieties and treatment not being significant.

In the analysis of variance of weight of tops for the second experiment, the treatment, variety, and interaction terms were all significant at the 1 per cent. level. This indicates that, though the average effect of inoculation over all three varieties was significant, yet the varieties did not react similarly. The table of means shows that there is very little response to inoculation in the tops of Nabawa plants in the second experiment. The effect of inoculation on Nabawa tops in the first experiment was also small, though not sufficiently lower than the response in the other two varieties to cause a significant interaction term.

The differences between the weights of the roots and tops of the plants in the experiment in late summer were not significant. This result was probably owing to the effect of high temperature. In other experiments* made during a previous summer, after germination at 20°C., it was found that fewer plants manifested the usual symptoms than the same varieties did under cooler post-germination conditions. It was therefore probable that the development of the organism during the plant's early vegetative development was restricted by the influence of the climatic conditions prevailing in summer.

* Unpublished results.

The Moisture Alarm.

A New Commercial Instrument for Automatically Sorting Timber according to its Moisture Content.

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Summary.

The capacity type electrical moisture meter described in the August, 1937, issue of this *Journal* has been modified to meet the present requirements of the Australian timber industry and has been subjected to extensive trial under commercial conditions. The new instrument is being marketed by a Melbourne engineering firm under the trade name "Moisture Alarm."

1. Introduction.

In the August, 1937, issue of this *Journal* the authors published a detailed description of a new instrument for determining the moisture content of timber. The principle of this instrument was the estimation of moisture content by its effect on the dielectric constant of timber. This instrument was favorably received by the timber trade, and commercial manufacture was considered by a firm of engineers in Melbourne.

An examination of the probable market led to the belief that the heavy expense which would be involved in standardizing instruments and calibrating them was not justified. It also appeared that the people who would be likely to instal this equipment already had a moisture meter and that their chief interest lay in applying the automatic signalling feature to moving timber, e.g., boards entering or leaving a moulding or planing machine. Consequently, attention was concentrated on meeting this need by simplifying the original instrument so that its only function would be to light a warning lamp whenever timber wetter than a pre-selected maximum was tested.

Numerous difficulties were encountered, some of these being the choice of the most suitable relay and signal lamp, the construction of the most suitable test electrodes, the matching of component parts, sharpening the response to moisture content changes, overcoming time-lags and electrical instability due to rapid variations in plate current, and reducing to a minimum the effect of sawdust, shavings, and movement of the timber on the instrument's estimation of moisture content. In due course, the instrument and its associated electrode shown in Plates 1 and 2 evolved. The equipment has been tested thoroughly under commercial conditions, and is expected to meet the requirements of the timber trade. For convenient reference, the instrument is being called the "Moisture Alarm."

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2. Description of the Moisture Alarm.

The instrument is designed to give an alarm by lighting a lamp whenever timber wetter than a pre-selected maximum passes between two metal plates fixed one above and one below timber moving on a conveyor or feeding into or out of a planing, moulding, or other machine. Plate 1 shows the instrument itself, Pl. 2, Fig. 1, the upper electrode equipment fixed to a moulding machine, and Pl. 2, Fig. 2, the adjustable bracket by which the electrode equipment is attached to the moulding machine.

The chief features of the instrument may be noted from Plate 1. On the left hand end, which cannot be seen, there is a socket to receive a plug and leads from a 200 to 250 volt alternating current power supply. On the right hand end, are an insulated terminal, a bare terminal, and a socket to receive a plug and leads to a 200 to 250 volt, 5 watt, neon lamp of the type used for night lights. From the insulated terminal, a wire is taken to a metal electrode which rests on the top of the timber to be tested (see Plate 2) and from the bare terminal a wire is taken to another metal plate on which the timber stands, this plate also being connected to earth. Where the equipment is to be used for testing timber passing through a planer or moulder, the metal bed plate of the machine takes the place of the bottom plate.

On the front panel there is a graduated dial and a knob which controls the signal lamp. The perforated aluminium article on top of the cabinet is a ventilator which, together with a ventilator in the floor of the cabinet, allows a stream of air to cool the valves inside.

From Pl. 2, Fig. 1, it will be seen that the upper electrode is attached with countersunk thumb screws to a piece of bakelite and a mild steel weight which in turn are connected by a hinge to a strip of canvas-bakelite attached to a bracket fastened to the framework of the moulding machine.

Pl. 2, Fig. 2, shows the details of the bracket used on this particular moulding machine (Robinson). The main feature is that it is slotted vertically and horizontally to allow the end of the canvas-bakelite strip to be raised or lowered and moved from side to side so that the test plate rests on the timber in a central position. Some other arrangement may be necessary with Yates and other machines, but the attachment presents no special difficulty.

3. Installation and Use.

The instrument may be placed in any convenient position, but it is desirable to keep the lead from the insulated terminal to the "live" electrode as short as possible, taut, and either away from all metal objects or else firmly fixed so that it cannot move in relation to them. The lead from the bare terminal should also be short, but in this respect it is not as important as the other lead. The leads from the power supply and to the signal lamp are not sensitive and their length does not matter. The signal lamp should be placed where it will be seen sub-consciously and yet not be in the way of the operator.

The instrument is not calibrated in any way, the graduations on the scale being arbitrary ones provided so that the operator may record in a note book the settings which he must find out for himself in the

following way. Say, for example, the first parcel of timber to be sorted was a parcel of flooring boards and it was desired to sort out any which had a moisture content exceeding 15 per cent., the procedure is then as follows. Allow one board to run between the electrodes and turn the control knob until the signal lamp lights; make a note of the dial reading. Test the moisture content of this board with a "Blinker" or other moisture meter. If it is, say, 12 per cent., and the knob is left in this position, the lamp will light whenever a piece of timber with 12 per cent. or a greater moisture content passes. Now turn the knob a little, say two graduations, so that the lamp will not light unless a piece with a moisture content higher than 12 per cent. passes. The next step is to start machining. If eventually a board in passing lights the lamp, turn the knob until the light goes out and note the dial reading. If, for example, this board had a moisture content of 18 per cent., then, knowing the dial settings for 12 per cent. and 18 per cent., a fairly good estimate of the dial setting corresponding to 16 per cent. can be made. This information should be noted in a book, so that on the next occasion this class of product is to be machined the dial setting will be known.

4. Acknowledgments.

The authors wish to acknowledge the assistance received from Messrs. A. H. Lane and F. L. Hopkins of the Precision Engineering Co., Melbourne, who co-operated in the development of the present commercial instrument from the laboratory model. They also wish to thank the Victorian Forestry Commission for providing facilities for testing at its Seasoning Works at Newport.

PLATE 1.

(" The Moisture Alarm." See page 258).

The Moisture Alarm showing control knob, socket for signal lamp leads, and terminals.

[*To face page* 260.]

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PLATE 2.

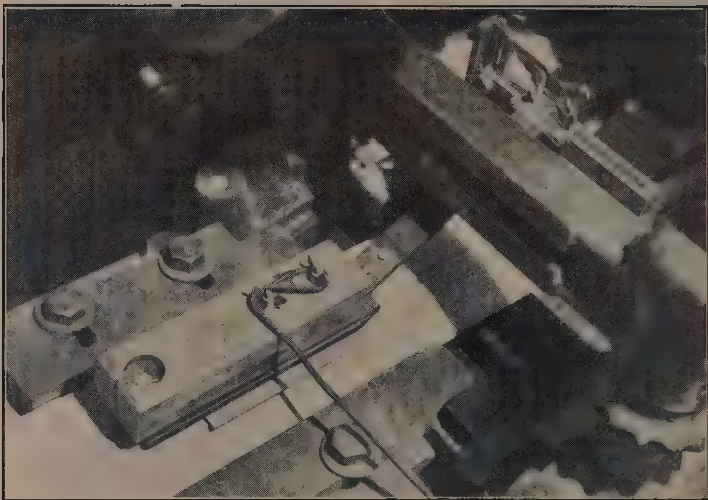

FIG. 1.—The "live" electrode showing plate, connecting wire, weight, and hinged arm.

FIG. 2.—Mounting bracket showing method of obtaining vertical and horizontal adjustment.

Some Characteristics of Soils used for the Cultivation of Peanuts (*Arachis*) in the Northern Territory of Australia.

*By J. A. Prescott, D.Sc.**

Summary.

Soils utilized for the cultivation of peanuts principally at Daly River and Katherine in the Northern Territory have been collected and subsequently examined in the laboratory. The soils are brown in colour, light textured, and reasonably fertile. The phosphate content suggests a probable response to phosphatic fertilizers. Soils considered to be specially suitable show characteristic mechanical analyses.

The cultivation of the peanut in the Northern Territory is the main agricultural operation of any commercial importance and is a relatively recent development. The industry began about 1926, and the number of cultivators reached its maximum in 1930 when 57 growers were registered. Since that time the number of farmers has declined, and in 1937 some 35 growers only were actively engaged in peanut cultivation. The two main centres of cultivation are Daly River and Katherine. Former centres at Adelaide River and Mataranka have been abandoned. The rainfall at Katherine is 38 inches, the greater proportion of which falls in the five summer months, November to March. The climate is thus typically monsoonal in character and is comparable with that of other centres where the cultivation of peanuts is important. One such noted centre is Kano in Northern Nigeria, and the monthly records of Katherine and Kano are given below for comparison. These records have been kindly made available by the Commonwealth Meteorologist and by Dr. C. E. P. Brooks of the London Meteorological Office. The seasonal rainfall is indicated by heavier type.

—	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Katherine (64 years)	**8·75**	**7·88**	**6·40**	1·17	0·22	0·11	0·02	0·02	0·25	1·16	**3·48**	**8·25**	37·71
Kano (23 years) ..	0·01	0·05	0·09	0·48	**2.40**	**4·55**	**7·99**	**11·95**	**5·59**	0·42	0·00	0·02	33·55

The soils favoured for the cultivation of the crop occur on the sandy alluvium in the immediate vicinity of the Daly and of the Katherine Rivers—these alluvial flats are 60 to 80 feet above the dry-season level of the river and are of widest extent at Katherine, and it is at the latter centre, within easy reach of the railway, that most progress is being made. At the Daly settlement until recently only water transport was available, but increasing use is being made of motor transport to the railway siding at Stapleton. The farms here are restricted to the upper tidal reach of the river, 80 miles from the mouth.

The data recorded are the result of an examination in the laboratory of samples collected in July, 1937, during a visit of reconnaissance in the Territory. Most of the farms were visited, and field notes were

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taken. The soils of the Katherine farms have a brown surface with red subsoils—those of the Daly tend towards a grey colour particularly in the case of farms a few miles down stream of the police settlement. In texture they range from very fine sandy loams or silt loams in the surface to light clay loams at the heaviest in some of the deeper horizons. Texture is exceedingly important in the cultivation of the peanut, as the crop must lift cleanly without any adhering soil. The soil must also be sufficiently loose for the seed pods to bury themselves readily in the ground.

The details relating to the location and analyses of the samples are recorded in the following list and in Table 1.

LIST OF SOIL SAMPLES.

5250–5252.—Profile from abandoned farm, Adelaide River, farm 114.
5270–5271.—Profile from cleared and abandoned farm, Mataranka, farm 7.
5272–5274.—Profile from cleared area, in grass, Daly River, farm 3.
5275.—Surface soil. Daly River, farm 39. Light drifty soil.
5276.—Surface soil. Daly River, farm 15.
5277.—Surface soil. Daly River, farm 26.
5278.—Surface soil. Daly River, farm 41. Very suitable soil.
5279.—Surface soil. Daly River, farm 42.
5280.—Surface soil. Daly River, farm 2.
5281.—Surface soil. Daly River, farm 32.
5282.—Surface soil. Daly River, farm 38. Very suitable soil.
5284–5287.—Profile. Katherine, farm 173.
5288–5291.—Profile. Katherine, farm 137.
5292–5295.—Profile. Katherine, farm 210; in peanuts since 1931.
5296.—Surface soil. Katherine, farm 210; first crop, away from river bank.
5297.—Surface soil. Katherine, farm 210; first crop, near to river bank.
5298.—Surface soil. Katherine, farm 164. Considered excellent soil type.
5299.—Surface soil. Katherine, farm 147.
5300.—Surface soil. Katherine, farm 167.

In spite of the relatively short experience of the growers in the Territory, some local opinions are already being expressed with regard to the suitability or otherwise of the soils on different farms or portions of a given farm. The reason for the failure at Adelaide River and Mataranka is not altogether clear, except possibly that the rainfall at the latter centre is probably near to the critical value for this crop. The presence or absence of suitable strains for rhizobium may be important, but on the farms themselves no difficulty was experienced in finding nodules on the roots of seedling and older plants. Presumably, the shell of the peanut, as a result of its formation underground, carries a suitable strain of the nodule organism, thus readily infecting the seed during the process of shelling. The Soils Division is, however, isolating suitable strains of Rhizobium to meet any possible future demand.

The content of the soils in plant foods varies over a relatively wide range. At Daly River the range for potash in the surface soils is from 0.144 to 0.252 per cent. of K_2O and at Katherine from 0.252 to 0.502 per cent. These ranges are closely related to differences in texture, but, after allowing for these differences, the soils at Katherine appear to be intrinsically richer in potash than those of Daly River.

TABLE 1.—ANALYSES OF SOILS FROM PEANUT FARMS IN THE NORTHERN TERRITORY.

Locality	Adelaide River.			Mataranka.		Daly River.			Daly River.							
Soil Number	5250	5251	5252	5270	5271	5272	5273	5274	5275	5276	5277	5278	5279	5280	5281	5282
Depth in inches ..	0–9	9–24	24–36	0–6	9–24	0–9	9–26	26–40	0–6	0–4	0–9	0–9	0–9	0–9	0–9	0–6
Mechanical Analysis—	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Coarse sand	16·9	17·9	14·0	51·6	48·6	11·3	20·8	16·3	38·2	30·2	19·7	24·9	45·6	43·2	36·7	28·7
Fine sand	69·2	65·5	64·2	37·5	35·8	75·3	64·6	68·9	54·9	59·2	67·8	62·7	46·8	46·4	53·8	62·8
Silt	7·6	8·2	11·7	2·1	1·7	4·1	3·9	3·9	2·2	3·0	4·6	3·4	2·4	3·3	2·5	2·6
Clay	5·0	8·2	10·4	7·5	13·5	7·7	9·6	9·7	3·9	4·9	6·5	7·0	4·2	5·5	5·5	5·0
Loss on acid treatment	0·2	0·2	0·2	0·4	0·2	0·5	0·5	0·4	0·3	0·4	0·6	0·7	0·5	0·5	0·5	0·3
Moisture	0·3	0·4	0·5	0·5	0·5	0·8	0·9	1·1	0·4	0·5	0·7	0·8	0·4	0·6	0·6	0·5
Chemical Analysis—																
Total soluble salts ..	·012	·008	·006	·020	·006	·006	·004	·004	·006	·009	·011	·019	·006	·007	·010	·006
Total nitrogen ..	·035	..	..	·034	..	·037	..	..	·020	·034	·042	·047	·031	·036	·041	·024
Total potash (K_2O) ..	·260	..	..	·086	..	·263	..	..	·144	·188	·215	·252	·162	·197	·209	·184
Total phosphate (P_2O_5)	·021	..	..	·019	..	·029	..	..	·017	·019	·042	·040	·023	·037	·028	·045
Reaction pH ..	6·8	6·2	5·9	7·4	7·3	6·9	7·2	7·3	7·1	6·9	6·4	8·3	6·6	6·5	6·9	6·7

Locality	All Soils from Katherine.																
Soil Number	5284	5285	5286	5287	5288	5289	5290	5291	5292	5293	5294	5295	5296	5297	5298	5299	5300
Depth in inches	0–6	6–18	20–30	30–42	0–4	4–12	12–30	30–42	0–9	9–22	22–30	30–42	0–9	0–9	0–8	0–7	0–8
Mechanical Analysis—	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Coarse sand	5·6	4·4	3·7	4·3	0·6	0·4	0·2	0·2	3·3	3·2	2·8	2·1	1·3	3·4	17·6	6·5	3·3
Fine sand	77·6	79·5	77·6	74·4	76·0	76·1	67·8	64·9	83·7	82·9	81·3	78·9	70·2	82·8	72·0	83·4	82·2
Silt	6·2	6·3	6·0	7·2	15·0	13·8	13·8	14·6	6·2	7·2	6·5	6·8	12·2	6·9	4·2	4·6	5·6
Clay	7·5	8·4	11·9	13·2	7·4	9·8	18·4	20·1	5·5	6·5	8·8	11·4	10·6	5·2	4·7	5·3	7·4
Loss on acid treatment ..	0·8	0·6	0·5	0·4	0·5	0·4	0·4	0·4	0·5	0·4	0·3	0·4	1·3	0·5	0·4	0·2	0·4
Moisture	0·9	0·8	0·9	1·0	0·8	0·7	1·1	1·2	0·6	0·5	0·6	0·8	1·5	0·5	0·6	0·4	0·7
Chemical Analysis—																	
Total soluble salts	·041	·013	·008	·008	·011	·005	·004	·003	·008	·005	·006	·005	·047	·028	·027	·007	·036
Total nitrogen	·078	·032	·020	·018	·046	..	..	..	·031	·018	·013	..	·102	·034	·055	·027	·040
Total potash (K_2O)	·422	·396	·400	·475	·502	..	..	..	·339	·382	·426	..	·486	·327	·252	·252	·374
Total phosphate (P_2O_5) ..	·021	·028	·031	·029	·028	..	..	..	·023	·020	·022	..	·045	·026	·027	·021	·024
Reaction pH	8·1	7·9	7·8	7·7	6·9	6·6	6·2	6·1	7·3	7·4	7·4	7·5	8·0	8·3	8·5	6·8	6·9

The range for phosphate is from 0.019 to 0.045 per cent. of P_2O_5 at Daly River and from 0.021 to 0.045 per cent. at Katherine. For such restricted localities and uniform parent alluvium, these ranges are rather wide, and some local differences in fertility from farm to farm may be expected. Owing to the cost of transport the use of chemical fertilizers is not generally attempted even at Katherine, but the above levels for phosphate suggest that some benefit should be derived from the use of superphosphate. A mineralogical examination of the fine sand fraction of a number of these soils did not reveal apatite in any abundance, and this examination did not suggest that the soils would be particularly rich in phosphates.

The suitability of these soils for the cultivation of the peanut is more probably related to the texture as revealed in the mechanical analysis. From Table 1 it will be noted that the proportion of clay in the surface soils is not high in any of the samples, and that the principal difference between the soils from Daly River and from Katherine lies in the relative amounts of coarse and fine sands. In the triangular diagram (Fig. 1) the mechanical analyses of the two groups have been plotted to show this particular feature. It will be noted that those soils considered

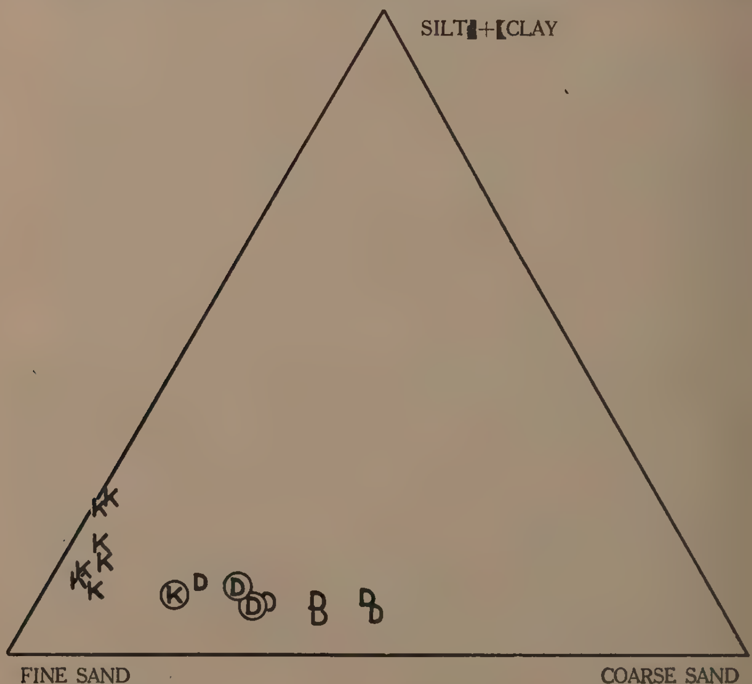

Fig. 1.—Diagram illustrating the mechanical analyses of soil used for the cultivation of the peanut in the Northern Territory.

D: Surface soils from Daly River.

K: Surface soils from Katherine.

Soils considered to be specially suitable are indicated by a circle.

to be suitable for the crop approach each other in physical character although the two groups are quite distinctive otherwise. On the sands separated from the samples during the process of mechanical analysis, detailed analysis was carried out by means of sieves, and from these analyses the distribution curve of the particle sizes of the non-colloid mineral fractions of these soils was determined. The curves for the soils considered to be particularly suitable in the light of local experience are given in Fig. 2.

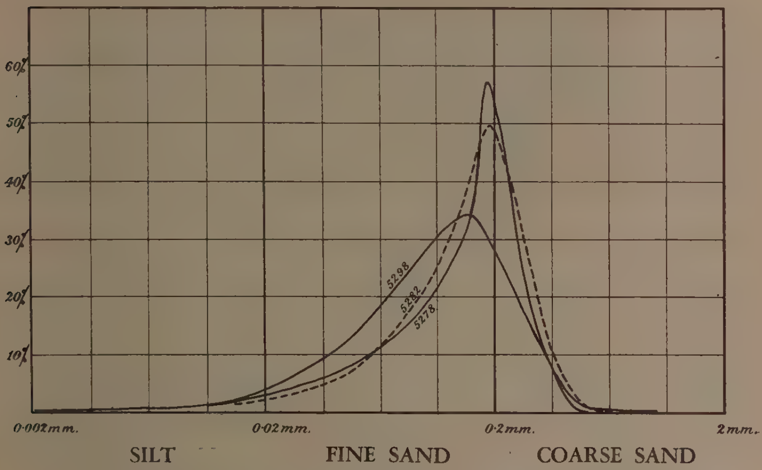

Fig. 2.—Distribution curve of the particle dimensions of the non-colloid fraction (silt + fine sand + coarse sand) of three soils considered to be specially suitable for the cultivation of peanuts.

Acknowledgments are due to Mr. H. K. C. Mair, Superintendent of Agriculture in Darwin, for his guidance in the Northern Territory, to Mr. C. H. Williams and Mr. J. G. Baldwin for the analytical work, and to Mr. R. L. Crocker for a mineralogical report on the samples.

The Growth of Micro-organisms on Ox Muscle.

III. The Influence of 10 per cent. Carbon Dioxide on Rates of Growth at −1°C.*

By W. J. Scott, B.Agr.Sc.†

Summary.

Studies of microbial growth in 10 per cent. CO_2 at — 1° C. have been made using ox muscle of known water contents as the substrate.

On muscle of normal water contents growth of *Achromobacter* was usually reduced to between 0.4 and 0.5 of the rates in air, for *Pseudomonas* to approximately 0.25, and to 0.46, 0.55, and 0.83 for three species of yeasts belonging to the genera *Candida, Geotrichoides,* and *Mycotorula,* respectively.

The critical muscle water contents for growth were always slightly higher than in air, and, for bacteria, the efficiency of 10 per cent. CO_2 as a growth inhibitor increased with decreasing muscle water contents.

The application of the findings to the transport of chilled beef is discussed.

1. Introduction.

In the previous papers of this series (1, 2) the results show the influence of substrate water content and temperature on the rates of growth in air. However, for the transport of chilled beef at — 1.4°C. from Australia to Great Britain, a storage environment containing 10 per cent. carbon dioxide is regularly employed. For a range of muscle water contents, it is important, therefore, to know the relative rates of growth of various micro-organisms in such an atmosphere. The present experiments have been conducted to determine these rates of growth for some of the more important microbial species causing spoilage of Australian chilled beef.

2. Experimental.

All experiments were made on uniform thin slices, of the *biceps femoris* muscle, which were inoculated after equilibration at various predetermined water contents. The technique for these operations has been already described (1). Preliminary experiments showed that the presence of 10 per cent. carbon dioxide had no measurable effect on the vapour pressure isotherm of the ox muscle. It was therefore more convenient to make the preliminary equilibration in air, and then, immediately after inoculation, the storage atmosphere was introduced. As in the previous experiments, the muscle was stored over sulphuric acid solution in the glass desiccators used for equilibration.

Introduction of Carbon Dioxide.

The storage atmosphere was drawn by a vacuum pump from an adjacent gas-tight room which served as a reservoir. The gas mixture entering the desiccator was first washed through sulphuric acid solution of the required vapour pressure and then delivered through the acid in the bottom of the desiccator. Both inlet and outlet tubes were fitted with glass stopcocks, and the rate of flow was adjusted by the stopcock on the suction (or pump) side of the desiccator. This method of

* The first two parts of this series appeared in this *Journal*, **9**: 177, 1936 and **10**: 338, 1937, respectively.

† An officer of the Section of Food Preservation and Transport.

regulation, which prevented any marked reduction of pressure within the desiccator, was found to be important, for, if the pressure were allowed to fall, the subsequent introduction of 10 per cent. carbon dioxide was often lethal to bacteria. When the storage reservoir contained 10.5 per cent. carbon dioxide and suction was continued for 10 minutes, the final concentration of carbon dioxide in the desiccator was 10.0 per cent. The desiccator maintained this concentration if the periphery of the ground glass joint was painted with melted petroleum jelly.

Estimation of Populations.

At intervals during storage at $-1°C. \pm 0.1$, muscle samples were removed for the estimation of microbial populations. The technique for these operations has already been described (1). Immediately prior to opening the desiccator for the collection of muscle samples, the internal atmosphere was tested for carbon dioxide concentration by means of Haldane's apparatus. These values were reasonably constant at 10.0 per cent. $\pm$ 0.5. Following the exposure to air for five to ten minutes during sampling, the carbon dioxide atmosphere was replaced according to the method described above. During these operations the muscle and the desiccator remained in the room at $-1°C$. The muscle sample was then reduced to a saline suspension for estimation of organisms by the agar plate method as previously described (1).

For the estimation of growth on agar, sterile surfaces in petri dishes were inoculated by the spraying method used for muscle. The petri dishes were subsequently stored over saline in air or 10 per cent. CO_2, and from time to time populations were estimated from a sample of nine discs, each of 1 sq. cm. in area.

3. Results.

Growth on Muscle.

The rates of growth on muscle have been determined for three strains of *Achromobacter*, two of *Pseudomonas*, and for three species of yeasts belonging to the genera *Geotrichoides*, *Candida*, and *Mycotorula*, respectively. The results for all organisms are summarized in Table 1 in which the rate of growth k (calculated as in (2)) in both air and 10 per cent. CO_2 is recorded for various values of substrate water contents. The relative tolerance to 10 per cent. CO_2 is expressed by the ratio $\frac{k \text{ 10 per cent. } CO_2}{k \text{ air}}$ which is seen to show considerable variation between different microbial species and, for any one species, to vary considerably with substrate water contents. The nature of these variations are summarized by the curves in Fig. 7. Also in Table 1 is shown the extent to which the lag period is increased in an atmosphere of 10 per cent. CO_2. In general, it appears that the lag period is in inverse ratio to the rate of growth measured during the exponential phase.

(i) *Achromobacteria.*

The results for two typical strains, which grow rapidly in air at $-1°C.$, proved to be very similar in 10 per cent. CO_2 and are shown graphically in Figs. 1 and 2. From the curves in these figures and the results in Table 1, it is apparent that the rate of growth gradually

TABLE 1.—SUMMARY OF RATES OF GROWTH AND LAG PERIODS AT —1°C. FOR VARIOUS RELATIVE HUMIDITIES IN BOTH AIR AND 10 PER CENT. CO_2.

Organism.	Per cent. r.h.	Rate of Growth k.			Lag (Days).	
		Air.	10% CO_2.	$\frac{10\%\ CO_2}{Air}$.	Air.	10% CO_2.
Achromobacter, No. 7 ..	99·3	0·065	0·0257	0·40	1	5
	98·5	0·064	0·0217	0·34	2	7
	98	0·060	0·0167	0·28	3	14
	97·5	0·060	0·0115	0·19	5	32
	97	0·057	0·00	0·00	8	> 40
Achromobacter, No. 483 ..	99·3	0·060	0·0277	0·46	1	5
	98·5	0·059	0·0225	0·38	2	7
	98	0·056	0·0173	0·31	3	12
	97·5	0·056	0·0154	0·27	5	25
	97	0·053	0·007	0·14	7	30
Achromobacter, No. 5 ..	99·3	0·043	0·0314	0·73	1	4
	97	0·040	0·0184	0·47	4	12
	96	0·034	0·00	0·00	12	> 40
Pseudomonas, No. 1	99·3	0·034	0·0077	0·23	8	> 40
Pseudomonas, No. 451 ..	99·3	0·032	0·011	0·29	5	> 40
Geotrichoides, No. Y9 ..	99·3	0·033	0·0182	0·55	4	5
	96	0·026	0·016	0·61	8	15
	94	0·017	0·0083	0·49	10	25
	92	0·011	0·00	0·00	25	>100
Candida, No. Y1	99·3	0·032	0·014	0·46	4	5
	96	0·022	0·013	0·59	9	14
	94	0·015	0·0059	0·40	16	30
	92	0·0075	0·00	0·00	50	>100
Mycotorula, Y15	99·3	0·0157	0·0131	0·83	6	8

falls from its maximum value at 99.3 per cent. r.h. (300 per cent. H_2O) and approaches zero at 97 per cent. r.h. (105 per cent. H_2O). The critical water contents for growth are therefore higher than in air, growth having been observed down to water contents of 90 per cent. when these strains were grown in air (1). On muscle of normal water

contents, the results in Table 1 show that the rates of growth in 10 per cent. CO_2 are 0.40 and 0.46 of the rates in air for strains No. 7 and 483 respectively.

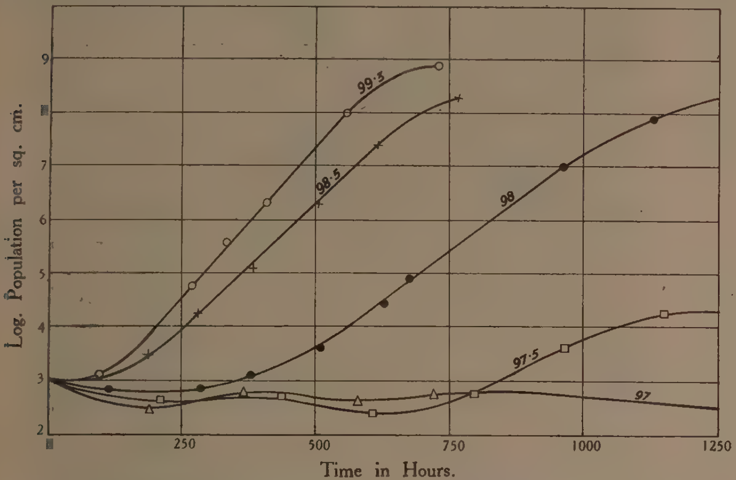

FIG. 1.—Logarithm time curves for *Achromobacter* No. 7 at various relative humidities in 10 per cent. CO_2 at $-1°C$. (The figures against the curves in Figures 1 to 6 indicate the relative humidity.)

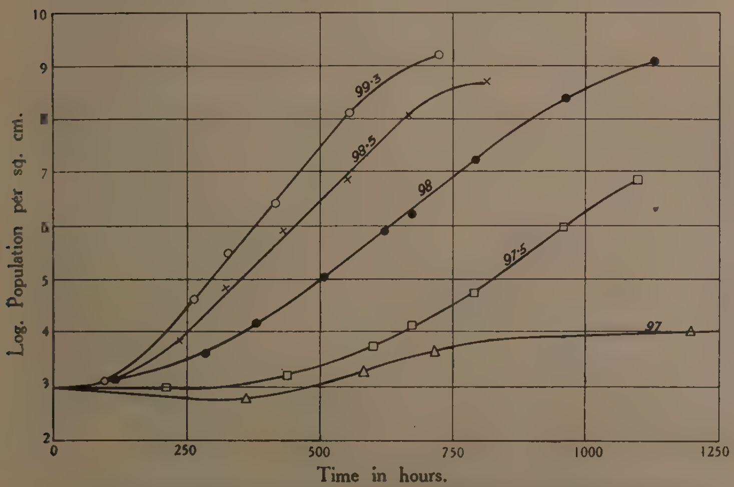

FIG. 2.—Logarithm time curves for *Achromobacter* No. 483 at various relative humidities in 10 per cent. CO_2 at $-1°C$.

Strain No. 5, a small Gram-positive organism which has been provisionally described as an *Achromobacter*, has a much greater tolerance to 10 per cent. CO_2, the ratio of the k values being 0.73 on muscle of normal water contents. This organism also shows a much greater tolerance to dry substrates and, although not previously reported, the figures in Table 1 show that in air, it grows at 96 per cent. r.h.

This greater tolerance to desiccation persists in 10 per cent. CO_2 and is evident in Fig. 3 which shows the relatively ready growth occurring at 97 per cent. r.h. Again, the critical water contents are higher than in air, as no growth occurred in 10 per cent. CO_2 at 96 per cent. r.h.

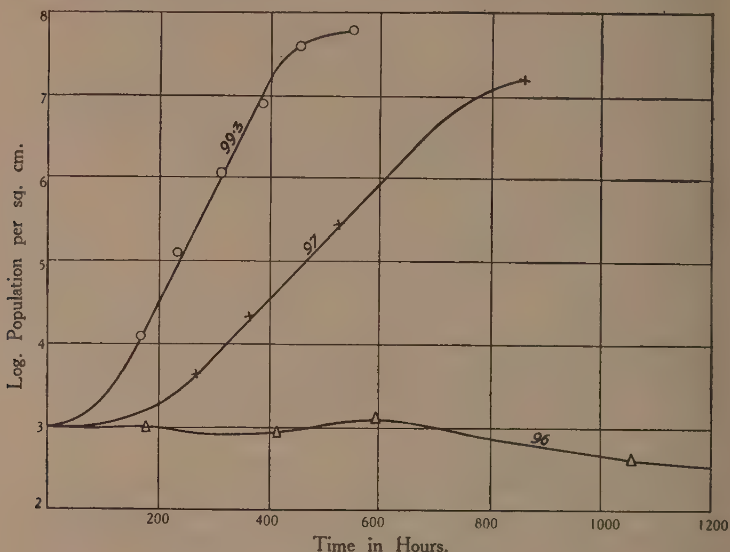

FIG. 3.—Logarithm time curves for *Achromobacter* No. 5 at various relative humidities in 10 per cent. CO_2 at $-1°C$.

The procedure was modified in some experiments to obtain a further check on the actual k value in 10 per cent. CO_2. This was done by allowing growth to begin in air and subsequently introducing the gas mixture during the exponential growth phase. In Fig. 6 the results of some such experiments are presented for *Achromobacter* No. 7. At 99.3 per cent. r.h., the rate of growth merely changes at the point of introduction of the gas, a result already obtained by Tomkins (3) for mould growth. At lower relative humidities, however, the result is more complex, and growth subsequent to the introduction of the gas mixture is frequently irregular. At 98 per cent. r.h., growth at first proceeds at a high rate ($k = 0.025$) similar to that obtaining on moist muscle, but this rate soon falls to a value ($k = 0.016$) more comparable with the mean value shown in Table 1. At 97 per cent. r.h., growth is maintained for only a short period, and subsequently death of many organisms occurs. Occasionally, there may be some subsequent recovery.

(ii) *Pseudomonas.*

Experiments with strains No. 1 and 451 showed that, on muscle of normal water contents, neither strain grew within six weeks from inoculation. Growth in 10 per cent. CO_2, however, was maintained when that atmosphere was introduced after growth began in air. Values for the rates of growth obtained by this procedure are given in Table 1. Both strains are markedly restricted by 10 per cent. CO_2, the ratio of the k values being 0.23 and 0.29, respectively.

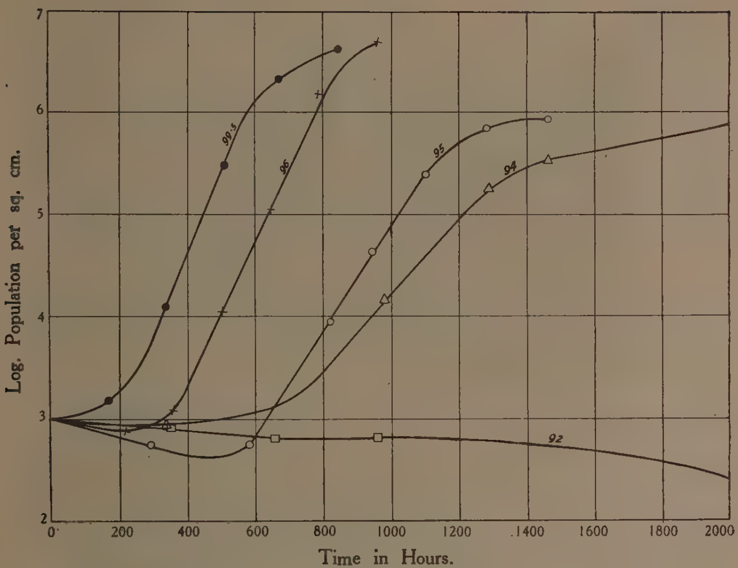

FIG. 4.—Logarithm time curves for *Geotrichoides* Y9 at various relative humidities in 10 per cent. CO_2 at $-1°C$.

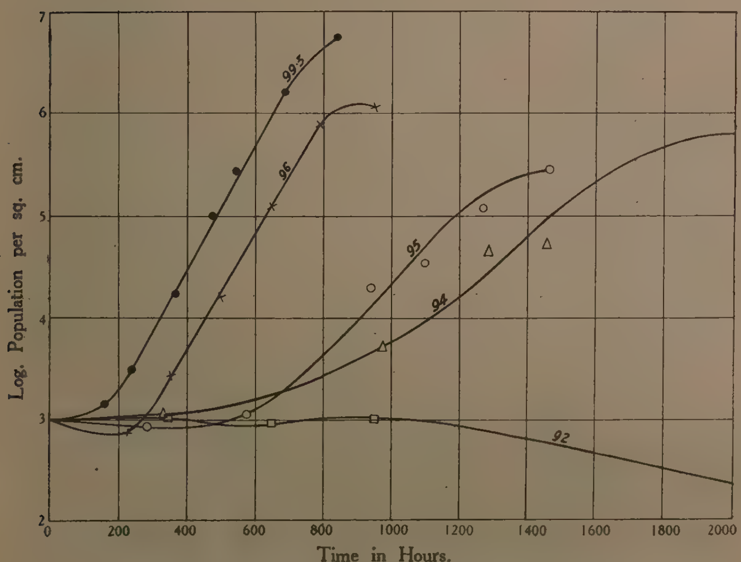

FIG. 5.—Logarithm time curves for *Candida* Y1 at various relative humidities in 10 per cent. CO_2 at $-1°C$.

(iii) *Yeasts.*

Summarized results for the three species are shown in Table 1. On muscle of normal water contents, *Mycotorula* Y15 is restricted only to 0.83 of its rate of growth in air, although for *Geotrichoides* Y9 (0.55) and *Candida* Y1 (0.46) the retardation of growth by 10 per cent. CO_2 is much greater. Results for the two latter species on muscle of various water contents are shown by the curves in Figs. 4 and 5. From these curves, it is seen that no growth has occurred at 92 per cent. r.h., showing that, for yeasts as well as bacteria, the critical water contents for growth are higher in 10 per cent. CO_2 than in air.

For both species very slight growth occurred at 93 per cent. r.h., and moderately vigorous growth at 94 per cent. r.h. From Table 1 and Fig. 7, it can be seen that the tolerance to 10 per cent. CO_2 is apparently greatest at intermediate water contents and not, as for bacteria, on muscle of 300 per cent. water contents.

Growth on Agar.

Additional information on the restriction of *Achromobacter* and *Pseudomonas* types was obtained from studies of the growth of other strains on agar surfaces. Also, as *Achromobacter* No. 5, a Gram-positive organism, had exhibited a high tolerance to 10 per cent. CO_2, a selection of Gram-positive organisms was grown on agar. Summarized results for air and 10 per cent. CO_2 are given in Table 2. For

TABLE 2.—SUMMARY OF RATES OF GROWTH AND LAG PERIODS AT $-1°C$. ON AGAR SURFACES IN BOTH AIR AND 10 PER CENT. CO_2.

Organism.		Rate of Growth k.			Lag (Days).	
		Air.	10% CO_2.	10% CO_2. / Air.	Air.	10% CO_2.
Achromobacter, 144 ..		0·053	0·026	0·49	1	3
Achromobacter, 610 ..		0·060	0·023	0·39	..	..
Achromobacter, 696 ..		0·024	0·0087	0·36	3	45
Achromobacter, 716 ..		0·045	0·018	0·40	2	6
Pseudomonas, 687 ..		0·029	0·0072	0·25	4	15
Pseudomonas, 760 ..		0·035	0·014	0·40	4	16
Miscellaneous Gram positive Bacteria	527	0·026	0·00	0·00	7	> 50
	535	0·030	0·018	0·60	2	14
	625	0·011	0·00	0·00	15	> 50
	634	0·025	0·00	0·00	3	> 70
	723	0·024	0·00	0·00	10	> 50
	776	0·028	0·00	0·00	5	> 70
	801	0·010	0·00	0·00	13	> 50

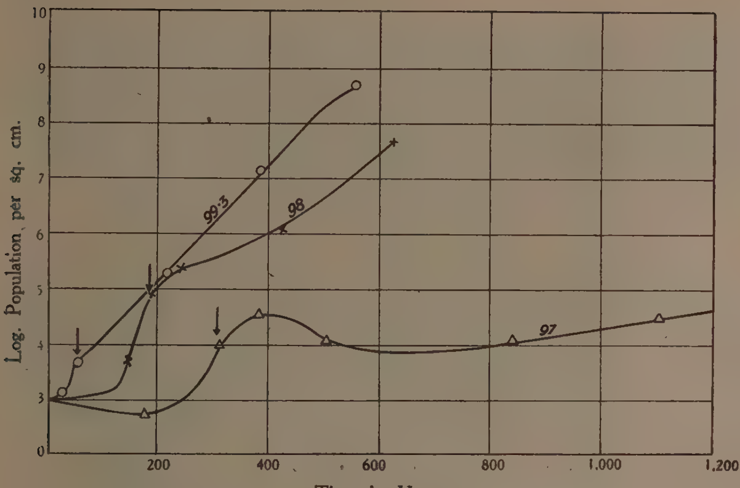

FIG. 6.—Logarithm time curves for *Achromobacter* No. 7 at various relative humidities at $-1°C.$ when 10 per cent. CO_2 is introduced after growth begins in air. (Time of introduction of CO_2 indicated by the arrows.)

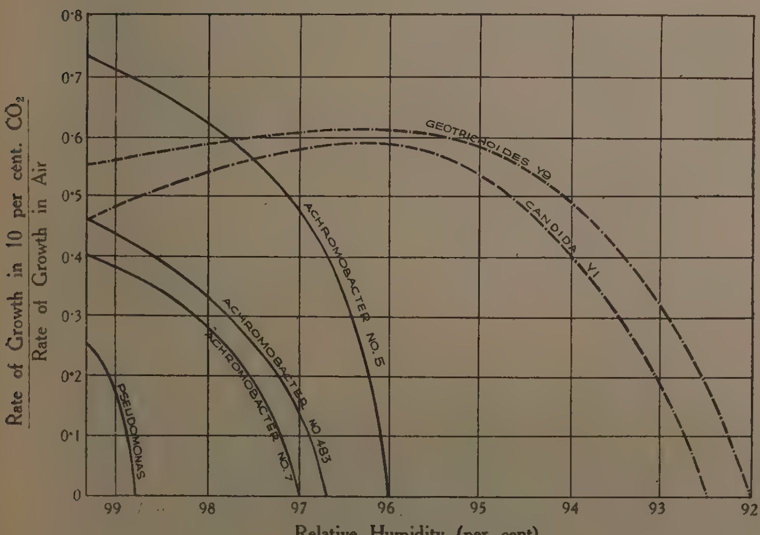

FIG. 7.—The relation between tolerance to 10 per cent. CO_2 and the relative humidity at $-1°C.$ for various micro-organisms.

Achromobacter and *Pseudomonas* the extent of retardation is in general agreement with the values already determined for the strains grown on muscle. Of the Gram-positive organisms, No. 535 shows a relatively high tolerance of 0.60, but, for the remainder, no growth was obtained during a minimum of seven weeks' exposure. The considerable extension of the lag period suggests, however, that high tolerance to 10 per cent. CO_2 is not generally conferred on these types.

4. Discussion.

(i) *Achromobacteria.*

With the exception of strain No. 5, which has only occasionally been isolated, these types grow on muscle of normal water contents in 10 per cent. CO_2 at $-1°C.$ at rates which lie between 0.4 and 0.5 of the rates in air. These results agree well with those of Haines (5) who found that, at 0°C., several species of *Achromobacter* were able to grow at approximately half the rates obtaining in air. In these experiments it is shown that further retardation results when the bacteria are grown on muscle of lower water contents (Fig. 7). The increased inhibition is not great at water contents above 180 per cent., but reduction of the water contents below this level increases the relative retardation at a rapidly increasing rate, the limiting water contents for growth being reached in the range 100 to 120 per cent. At relative humidities of 98 per cent. and below, the results have been more variable than for air stored experiments. This variation applies more particularly to the lag period which, for *Achromobacter* No. 7 at 98 per cent. r.h., has varied between 10 and 25 days, and in one experiment at 97.5 per cent. r.h. was extended to 45 days.

In general, however, it may be stated that at 98 per cent. r.h. (145 per cent. H_2O) the tolerance to 10 per cent. CO_2 is reduced approximately to 0.3 and at 97.5 per cent. r.h. (125 per cent. H_2O) the rate of growth is only 0.2 of the rate in air. This increased efficiency of 10 per cent. CO_2 at lower substrate water contents is confirmed by the results obtained when the gas mixture is introduced after the bacteria are already growing on muscle (Fig. 6). An inspection of the results reveals that *Achromobacter* No. 483 is slightly more resistant to substrate desiccation than is *Achromobacter* No. 7, a result already indicated by the air stored experiments (1).

For *Achromobacter* No. 5 the retardation by 10 per cent. CO_2 also increases with decreasing water contents (Fig. 7), although at 97 per cent. r.h. its rate of growth in 10 per cent. CO_2 is still approximately half the rate in air.

(ii) *Pseudomonas.*

Results obtained for members of this genus indicate greater retardation by 10 per cent. CO_2 than is general for *Achromobacter.* The results of Coyne (4) and Haines (5) do not indicate any marked differences from *Achromobacter*, and it is probable, therefore, that within the genus there is considerable variation in the amount of retardation effected by 10 per cent. CO_2. In view of the susceptibility of these strains to substrate desiccation in air, it is not likely in atmospheres of 10 per cent. CO_2, that they will grow at water contents very much less than 300 per cent.

(iii) *Asporogenous Yeasts.*

Although only three species were tested, it seems likely that the general resistance to 10 per cent. CO_2 will be greater than for bacteria. Most marked in this respect is the species of *Mycotorula* which suffers very slight retardation. The divergence from the bacterial results increases as the muscle becomes drier, and it appears, that, although the rate of growth falls continuously with moisture content, relative retardation may actually be least at moisture contents of approximately 100 per cent. (Fig. 7).

A point of possible interest is that the order of decreasing tolerance of the three yeasts to 10 per cent. carbon dioxide is also the order of decreasing tolerance to substrate desiccation. A similar agreement obtains for the four bacterial types *Achromobacter* Nos. 5, 7, and 483 and *Pseudomonas* No. 451. While no explanation of this relation is offered, it is pointed out that the odds against its chance occurrence, $4! \times 3!$, exceed the usual standard for statistical significance.

(iv) *Practical Applications.*

The application of these results to the commercial transport of chilled beef in atmospheres containing 10 per cent. CO_2 is of considerable practical importance. As spoilage is largely caused by excessive microbial proliferation in the superficial tissues usually within the first two millimetres, it is evident that microbial growth may be retarded by reducing the water contents of these muscle tissues. Considering the exposed muscle surfaces at the time of shipping, it has been found that the water contents of the surface layer approximately 1 mm. thick usually lie between 100 and 150 per cent. (6). This applies only to those surfaces exposed during slaughtering, the figures for muscle water contents on areas such as the cut rib seldom being much less than 300 per cent. Estimations made during the discharge of cargoes in England* have shown the figures to be usually in the range 150 to 200 per cent., with a general minimum of 100 and a maximum of 250 per cent., the values being independent of those obtaining at the time of shipping. As the most important agents of spoilage are various strains of *Achromobacter,* it appears that considerable practical benefit may ensue if the rates of evaporation maintained on ship-board result in the meat being discharged with superficial muscle water contents within the range 100 to 150 per cent. The rates of evaporation permissible would, of course, be limited by the possibility of loss of bloom due to excessive weight loss and withering of the quarters. However, the arrival of some cargoes with low superficial water contents and no apparent withering indicates that such control of microbial development might well prove feasible. Although the above remarks suggest that maintenance of the surface millimetre of muscle at water contents between 100 and 150 per cent. may provide valuable additional retardation in 10 per cent. CO_2, it must be remembered that the measured water contents are merely average figures for such a layer and give no indication of the moisture gradient. Moreover, intense surface desiccation does not necessarily arrest bacterial growth, but the bacteria tend to proliferate in the deeper layers where the water contents are more favorable for growth. On the surface of beef quarters, the

* By the Council's liaison officer, Mr. N. E. Holmes.

muscle layer containing the bacteria should always be regarded as neither uniform nor stationary, and, consequently, it is not easy to predict the rate of onset of spoilage merely from the measured water contents of the surface tissues. Obviously, consideration must also be given to variations in the tensions of both carbon dioxide and oxygen at various depths below the surface. At present, however, we have no complete data for the combined effects of water contents, and of oxygen and carbon dioxide tensions on bacterial growth, and, therefore, predictions of the rate of growth cannot be made with certainty.

Experimental evidence obtained in this laboratory (7) has shown that growth of *Achromobacter* No. 7 on beef quarters in 10 per cent. CO_2 continues slowly ($k = 0.015$) with muscle surface water contents as low as 70 per cent. There are at least two reasons for this result. Firstly, growth was proceeding in tissues of greater water contents, approximately 20 per cent. of the final population of 3×10^9 per sq. cm. lying at more than 2 mm. from the surface. Secondly, the results obtained by Hicks (8) indicate that, when ox muscle is dried at 0°C., the activity of the water in the surface tissues does not fall in accordance with the measured water contents at the surface. Hicks suggests that this is due to a migration of crystalloids from the surface to deeper layers. It appears, therefore, that measured water contents will always give an under-estimate of the activity of water in the surface tissues, the amount of the discrepancy depending on the extent to which crystalloids have moved from the surface. As a consequence, we may expect that microbial growth will be maintained in surface tissues whose water contents are below the critical values determined on equilibrated thin slices.

Another aspect of the results is that, on substrates of low water contents, *Achromobacteria* have an extended lag period in 10 per cent. CO_2. The extension of storage life by this means may be considerable, if, at the time of shipping, the microbial population is not actively proliferating. Conversely, it is not likely that there will be any marked lag period when carbon dioxide is introduced after unsatisfactory meatworks conditions have allowed extensive proliferation during chilling (6).

The above remarks refer to the typical psychrophilic strains of *Achromobacter* (such as No. 7 and 483) which are common spoilage agents of Australian chilled beef. For types such as *Achromobacter* No. 5, which, fortunately, are rare, control would be more difficult. For *Pseudomonas* it is unlikely that the types investigated here will be of any significance as spoilage agents when beef is transported in 10 per cent. CO_2. For the yeast species, the superficial muscle water contents prevailing during commercial shipments are never likely to cause any appreciable retardation of growth beyond the rates obtaining on muscle of normal water contents.

Although the results apply only to beef muscle, for quarter beef the major portion of the surface covering consists of connective tissue and fat. The relation of microbial growth to the water contents of such a substrate has not been determined, but the water reserves of the layer are known to be low (9). It is likely, therefore, that control of microbial growth by substrate desiccation will be less difficult for these tissues than for muscle. This has already been shown by Haines (10) for bacterial growth on beef fat at 0°C.

From the commercial aspect, the important principle is that the lower the water contents of the tissue supporting bacterial growth, the greater will be the efficiency of carbon dioxide as a growth-retarding agent, or, as stated by Brown (11) for moulds, "the carbon dioxide retarding factor has greatest effect when the energy of growth is small." In practice, however, bacterial control by drying is made more difficult by the tendency of the bacteria to penetrate to layers of higher water contents, and by the activity of the muscle water not being reduced in accordance with the muscle water contents.

5. Acknowledgments.

The author wishes to thank Messrs. Toledo-Berkel Pty. Ltd., Brisbane, for the loan of a high grade slicing machine, and the Queensland Meat Industry Board for providing the meat used in these experiments.

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A. Fruit.—In co-operation with the Department of Agriculture of Victoria.

Huelin, F. E., Tindale, G. B., and Trout, S. A., 1937.—The Cool Storage of Peaches in Air and Artificial Atmospheres. *J. Dept. Agric. Vic.*, **35**: 609.

The average storage life of peaches stored in air at 0°C. is about six weeks. By storing in an atmosphere containing 8 to 10 per cent. of carbon dioxide, the storage life can be increased by about 50 per cent. The influence of maturity at picking time is discussed.

Tindale, G. B., Trout, S. A., and Huelin, F. E., 1935.—The Cool Storage of Plums. First Progress Report. *J. Dept. Agric. Vic.*, **33**: 552.

Owing to the limited storage life of all varieties, there is a considerable risk attached to the export of plums overseas. The fruit should be picked when fully grown but definitely immature, and should be promptly cooled and stored at a temperature of 31°F. The ships' holds should be well ventilated to prevent accumulation of carbon dioxide in excess of 2 per cent.

Tindale, G. B., and Trout, S. A., 1934.—The Cool Storage, Handling, and Ripening of Pears. *J. Dept. Agric. Vic.*, **32**: 38.

Some of the factors influencing storage life of pears, with special reference to the William variety, are discussed, in relation to export overseas.

Tindale, G. B., Trout, S. A., and Huelin, F. E., 1938.—Investigations on the Storage, Ripening, and Respiration of Pears. *J. Dept. Agric. Vic.*, **36**: 34 and 90.

The optimum picking times, the effects of delaying storage, the maximum cold storage life, and the optimum ripening conditions for the main export varieties are discussed. The changes in colour, resistance to pressure, chemical composition, and respiration are given in detail. The chief forms of wastage are described.

Trout, S. A., and Tindale, G. B., 1935.—Storage and Ripening of Fruit with particular reference to William Pears. *Fruit World* (Melbourne), **36**: 99.

The William pear, like certain varieties of stone fruits, will ripen properly at cool storage temperatures, but requires a ripening temperature of 60° to 65°F. for the development of optimum flavour, juiciness, and texture.

Trout, S. A., and Tindale, G. B., 1938.—The Pre-cooling of Fruit in Relation to its Storage Life. Proc. 1938 Congress N.S.W. Institute of Refrigerating Engineers, Sydney.

The advantages and disadvantages of prompt cooling of several kinds of fruit are discussed. For the export of pears and stone fruits, prompt cooling after picking is essential, but for oranges and apples it is impossible to give any clear-cut decision for or against pre-cooling. The position is complicated by the influence of the variables of season, variety, maturity, and temperature-time relationships between picking and cooling.

B. Bananas.—In co-operation with the Queensland Department of Agriculture and Stock.

Hicks, E. W., 1935.—Notes on Mixed Ripe and Boiled Bananas and on Common Faults in Packing. *Fruitgrowers' Gazette,* Feb. 6th and 13th.

These notes, written primarily for banana growers, outline the precautions to be adopted on the plantations and during road transport to avoid wastage during rail transport to southern markets.

Simmonds, J. H., and Mitchell, R. S., 1937.—The Squirter Disease in Bananas with Special Reference to its Control. *Queensland Agric. J.,* **47**: 542.

This transport disease, often very prevalent in the fruit during the winter and spring months, may be controlled by dipping the fruit, either as singles or clusters, in 1 per cent. Shirlan A. G.

C. Meat.

Empey, W. A., 1933.—Studies on the Refrigeration of Meat. Conditions determining the Amount of "Drip" from Frozen and Thawed Muscle. *J. Soc. Chem. Ind.* (G.B.), **52**: 230T.

"Drip" is found to be similar, both in its chemical and physical constitution, to the relatively free fraction of muscle fluid which may be expressed from the cut surfaces of the same unfrozen muscle, and the susceptibility of a muscle to drip depends on the percentage and ease of expression of this loosely held muscle fluid. The extent of drip is dependent on the pH of the muscle, being at a minimum in muscle of pH 6.3 or slightly higher. Factors such as age, breed, sex, and variation in the rates of freezing and thawing have no definite influence on the susceptiblity of a muscle to drip.

Empey, W. A., 1938.—Some Problems Associated with the Development of the Chilled Beef Industry in Australia. *Country Life* (Queensland), **3**: No. 38, 7, and **3**: No. 40, 8.

This paper discusses the factors influencing the storage life of chilled beef, and stresses the part that graziers can play in the improvement of the "bloom" of the beef quarters.

Empey, W. A., Scott, W. J., and Vickery, J. R., 1938.—Notes on the Preparation, Cooling, and Transport of Export Chilled Beef. Proc. 1938 Congress N.S.W. Institute of Refrigerating Engineers (Sydney). *Refrig. Cold Storage, and Air Cond.,* **9**: No. 2, 21.

In order safely to export Australian chilled beef to Great Britain, certain rigid hygienic precautions must be adopted in the meatworks. In addition, certain physical conditions of the air during cooling and storage must be closely regulated. These conditions are analysed, with particular reference to their engineering aspects.

NOTES.

Work for the Secondary Industries—Financial Provision.

In a previous issue (Vol. 9, p. 237), it was reported that the Commonwealth Government had set up a Committee—the Secondary Industries Testing and Research Committee—to advise in connexion with the Government's desire to extend the activities of the Council into the field of the secondary industries. That Committee reported early in 1937; its report was subsequently tabled in Parliament and has recently been printed as a Parliamentary Paper (No. 30—F.2322—1938, Commonwealth Government Printer, Canberra).

Briefly, the Committee recommended that a National Standards Laboratory be established, that aircraft and engine testing and research work be initiated, that a research service be established to carry out investigations of value to the secondary industries, and that the Council's existing Information Service be extended so that it would be better equipped to obtain and disseminate information regarding scientific and technological matters.

The recommendations of the Committee have now been approved by the Government, and as one step towards putting them into effect a Bill—the Science and Industry Research Appropriation Bill, 1938—was introduced towards the latter end of the last Parliamentary session. It received the general support of all political parties in the House, and was finally passed by the Senate on the 28th June, 1938.

The Act appropriates the sum of £250,000. This amount will be paid into a Trust Fund for the purpose of financing the capital expenditure involved in the establishment of a National Standards Laboratory which will probably be erected in Sydney, an Aeronautical and Engine Testing Research Laboratory which will be built at Fisherman's Bend near Melbourne, for the setting up of various subsidiary establishments, and for the extension of existing establishments of the Council.

The proposed laboratory for aeronautical and engine testing work will be equipped in accordance with recommendations made in a report Mr. H. E. Wimperis, late Director of Research, Royal Aircraft Establishment, Farnborough, presented to the Government at the end of 1937. This report also was tabled in Parliament towards the end of the last session, and has been printed as a Parliamentary Paper (No. 29—F.2321—1938, Commonwealth Government Printer, Canberra). Prior to furnishing the report, Mr. Wimperis spent some six months in Australia making himself conversant with local conditions.

New Information Section of the Council.

In the previous note, it was stated that one of the recommendations of the Secondary Industries Testing and Research Committee concerned the enlargement of the information work that has been carred out by the Council for some time past.

Following the acceptance of this recommendation, the Secretary of the Council (Mr. G. Lightfoot) left Australia in June, 1937, on a visit to Europe and America in order to obtain first-hand knowledge of the work and organization of information services in those countries, and to establish contacts with organizations from which useful information could be obtained. His visit was assisted very largely by the Carnegie Corporation of New York which made a grant towards the cost involved.

Mr. Lightfoot returned to Australia in January, 1938, and then furnished a report to the Council on his observations. Briefly, he recommended—(*a*) the organization of an Information Service by the Council for the purposes visualized by the Secondary Industries Testing and Research Committee; (*b*) the reinforcement of the Information Service by the initiation of research work by C.S.I.R. in co-operation with industry; and (*c*) the extension of the Imperial Agricultural Bureaux plan so as to include branches of science and industry other than those relating to agriculture.

The functions which he recommended for the new body to carry out information work—and which functions have now been adopted—were:—

(i) The preparation of bibliographical references and abstracts of scientific papers, accompanied in appropriate cases by summaries of information, for the use of (*a*) the Council, its Executive Committee, and its other Committees; and (*b*) of scientific workers whether members of the Council's staff or otherwise.

(ii) The supply of scientific and technical information, in response to inquiries received from persons engaged in industry or from members of the public, including advice and assistance to persons who experience difficulties in manufacturing processes or the establishment of new industries.

(iii) The preparation of information relating to recent advances in the application of science to industry, new processes, &c., and the dissemination of such information through appropriate channels, e.g., Chambers of Manufactures, industrial associations, individual industrial establishments, trade journals, &c.

(iv) The preparation and publication of articles, so far as practicable in non-scientific terms, explaining the objects and results of researches undertaken by the Council in a form likely to be understood by those who would derive benefits from the application of the results.

(v) The preparation and issue from time to time to members of the Council, its Committees, to senior members of its staff, and to bodies corresponding to it in other parts of the Empire, of confidential statements summarizing the contents of reports received on its work.

(vi) The preparation and issue to the press of statements concerning the work of the Council.

(vii) The exchange of bibliographies, summaries of information, &c., with such institutions in other countries as may be arranged, and particularly with bodies corresponding to the Council in other parts of the Empire.

(viii) The editing and publication of the Council's quarterly Journal, Bulletins, Pamphlets, Annual Reports, and all other publications.

(ix) The distribution of the Council's publications.

(x) The control and development of the Council's Library.

(xi) The preparation and collection of exhibits demonstrating the work of the Council.

(xii) The maintenance of such indexes and other special records as are necessary for the above purposes.

(xiii) The provision in appropriate cases of secretarial services to Committees of the Council.

The above recommendations have now been approved, and an Information Section formed to carry out the proposed functions. It has been placed in charge of Mr. G. A. Cook who, for many years past, has been on the staff of the Council and of the Institute which preceded it.

Two other appointments have also been made to the new Section. One of these is that of Mr. E. J. Drake, who has had a wide experience in chemical industry for the last few years in the capacity of a consultant. The other appointment is that of Miss N. Repin, a graduate from the University of Sydney in chemical subjects, and who also has linguistic qualifications. One or two other appointments to the Section will in all probability be made in the near future.

Built-up Doors—The Strength of Different Designs.

Of late years, the use of built-up doors with flat plywood surfaces has become very popular. These doors are mainly of two types, namely, those consisting of a frame to which plywood is glued, and those with a solid built-up core on both sides by which veneers are attached.

In the former type there are two general methods of constructing the frame. In the first of these methods, the top, back, and bottom rails are tenoned into the mortised stiles, and the intermediate rails fastened to the stiles with corrugated fasteners made of metal; the second method is that in which all the rails are fastened to the stiles with corrugated fasteners. The latter is, of course, a much cheaper construction, and it is a matter of considerable interest as to whether it gives as satisfactory a finished article after the application of the plywood to both sides. Recently, tests were carried out by the Division of Forest Products to determine the relative strengths of the two types of doors. A number of frames and a number of finished doors were made up, using the two forms of construction. These were subjected to diagonal pressure in the Southwark Emery testing machine.

The mortised and tenoned frame, as expected, showed considerably greater resistance to distortion and to final destruction, being five times stronger and six times stiffer than the frame made with corrugated fasteners.

When, however, the completed doors were tested, it was found that so great is the strength developed by the gluing-on of the plywood that the differences due to two types of frame construction are completely swamped. This is shown by the following figures for finished doors :—

		Strength. lb.		Stiffness. lb./in.
(a) Mortised and tenoned construction	..	37,700	..	8,800
(b) Corrugated fastener construction	..	36,200	..	7,660

In other words, it has been shown that the cheaper form of construction gives a door equally as strong as the more expensive type, and from this point of view there is nothing to be gained by adopting the mortised and tenoned construction. This is a point of considerable interest and should be taken advantage of in cheapening the construction of this type of door.

As time permits, the Division proposes to carry out further tests on other factors of door construction and other built-up fittings.

Investigation on Reeds in Irrigation Channels.

For some time past the New South Wales Water Conservation and Irrigation Commission and the Victorian State Rivers and Water Supply Commission have been providing funds to enable one of the Council's investigators (Mr. R. W. Prunster) to work at Griffith, New South Wales, in an endeavour to evolve a satisfactory method of controlling cumbungi (*Typha latifolia*), a variety of bulrush which causes trouble in irrigation channels. The rush by its growth can seriously restrict the flow of water and can also in turn lead to sedimentation.

With the better knowledge of cutting treatments as a result of the investigations and the institution of a regular channel patrol, cumbungi is not now regarded so seriously as previously. On the other hand, the common water reed (*Phragmites communis*), although at present occurring in isolated patches in the irrigation channels, is apparently not controlled by cutting or by excavation in normal channel cleaning operations. For this reason it has been considered necessary to conduct experiments aimed at its eradication before it assumes serious proportions.

Arising out of this position, it is now proposed that arrangements should be made for the extension of Mr. Prunster's investigations to include experimental work on the control of the reed. The two Commissions mentioned above have agreed to find the extra funds involved.

Tests on Small Clear Specimens of Karri (*Eucalyptus diversicolor*).

*Contributed by Ian Langlands, B.E.E.**

In a previous number of this *Journal*†, the results of a systematic series of tests on the strength of green karri were published. The results of the tests on the air-dry timber are now available.

A comprehensive report on the complete tests is being prepared, but in the meantime it is considered advisable to publish the average figures. These are given in the following Table, the results of both the green and dry tests being given.

TABLE 1.—AVERAGE MECHANICAL AND PHYSICAL PROPERTIES OF KARRI.

Property.	Moisture Condition.	—
Moisture content—per cent.	Green	64
Nominal specific gravity (weight oven-dry, volume at test)	Green	0·690
	12 per cent.	0·820
Weight per cubic foot—lb.	Green	71
	12 per cent.	57·5
Shrinkage—		
Green to 12 per cent. moisture content—		
Radial—per cent.	..	4·8
Tangential—per cent.	..	9·5
Green to oven dry—		
Radial—per cent.	..	7·9
Tangential—per cent.	..	13·5
Static Bending—		
Fibre stress at limit of proportionality—lb./sq. in.	Green	7,640
	12 per cent.	11,800
Modulus of rupture—lb./sq. in.	Green	11,270
	12 per cent.	20,600
Modulus of elasticity—lb./sq. in.	Green	2,320,000
	12 per cent.	2,970,000
Work to limit of proportionality—in. lb./cu. in.	Green	1·44
	12 per cent.	2·65
Work to maximum load—in. lb./cu. in.	Green	9·5
	12 per cent.	20·8
Total work—in. lb./cu. in.	Green	24·8
	12 per cent.	39·6
Toughness—		
Radial—in. lb.	Green	206
	12 per cent.	268
Tangential—in. lb.	Green	201
	12 per cent.	223
Compression parallel to grain—		
Fibre stress at limit of proportionality—lb./sq. in.	Green	4,870
	12 per cent.	7,750
Maximum crushing strength—lb./sq. in.	Green	5,850
	12 per cent.	10,510
Modulus of elasticity—lb./sq. in.	Green	2,750,000
	12 per cent.	3,510,000
Compression perpendicular to grain—		
Fibre stress at limit of proportionality—		
Radial—lb./sq. in.	Green	1,130
	12 per cent.	1,330
Tangential—lb./sq. in.	Green	1,460
	12 per cent.	2,450

* An officer of the Division of Forest Products.

† Langlands, Ian.—Tests on Small Clear Specimens of Green Karri (*Euc. diversicolor*). *J. Coun. Sci. Ind. Res.*, 8: 228-230, 1935.

TABLE 1—*continued.*

Property.	Moisture Condition.	—
Hardness—		
Radial—lb.	Green	1,510
	12 per cent.	1,960
Tangential—lb.	Green	1,430
	12 per cent.	1,830
End—lb.	Green	1,460
	12 per cent.	2,080
Shear—		
Radial—lb./sq. in.	Green	1,190
	12 per cent.	1,950
Tangential—lb./sq. in.	Green	1,460
	12 per cent.	2,590
Cleavage—		
Radial—lb./in.	Green	380
	12 per cent.	505
Tangential—lb./in.	Green	535
	12 per cent.	730

Review.

"TROPICAL FRUITS AND VEGETABLES: AN ACCOUNT OF THEIR STORAGE AND TRANSPORT," by C. W. Wardlaw.

The Imperial College of Tropical Agriculture has recently published as Memoir No. 7 a most comprehensive summary of over 200 pages of the available information on the storage and transport of 150 tropical fruits and vegetables. Where information is available the various factors, such as variety, growing conditions, maturity at picking time, temperature and composition of the storage atmosphere, which affect the storage and transport of any one commodity have been considered in detail. This is the first time that the enormous task of summarizing all the available information on tropical fruits and vegetables has been attempted, and the Imperial College is to be congratulated on such an excellent and valuable contribution to the literature on food preservation. The value of the Memoir is further enhanced by its numerous references at the end of the subject-matter on each commodity. Among the numerous fruits and vegetables which have been listed are many unknown to Australians, and the cultivation of some of these products may prove worth while in our tropical regions.

The Memoir is strongly recommended to all interested in the growing, marketing, storage, and transport of tropical fruits and vegetables, for it shows how much has been achieved as the result of research and practical experience and how the difficulties are gradually being overcome. Copies of the publication which must eventually be regarded as a standard reference work by many people may be obtained (price 4s. 6d.) on application to the Editor "Tropical Agriculture," Imperial College of Tropical Agriculture, Trinidad, B.W.I.

S.A.T.

Obituary.

Mr. W. L. Geach.

Wilfred Leslie Geach, formerly an assistant research officer in the Division of Plant Industry, died on 11th May, 1938, after a long and painful illness. A native of Devon, Mr. Geach joined the British Army as soon as his age permitted, but he was too young to see active service in France. He served in Ireland as a member of the Devonshire Regiment, and subsequently graduated B.Sc. with first-class honours at Bristol University in 1925.

After spending some time in England on the investigation of storage moulds of tobacco, Mr. Geach went to India as plant pathologist to a rubber estate. About a year later, he returned to England, since the tropical climate proved injurious to his health. Soon after the inception of the Division of Plant Industry, he joined the staff as a member of the Section of Plant Pathology. His work dealt mainly with root rots of cereals and of field peas, and he published several papers on these subjects in the Council's Journal.

Mr. Geach was of a retiring and unassuming nature, and was respected amongst his colleagues for his perseverance and methodical painstaking work on problems which were often of a very disheartening nature. He was 38 years of age, and is survived by a widow and young daughter, to whom the deepest sympathy of the Division is extended.

Recent Publications of the Council.

Since the last issue of this *Journal,* the following publications of the Council have been issued:—

Bulletin No. 117.—" The Regional and Seasonal Incidence of Grasshopper Plagues in Australia," by K. H. L. Key, M.Sc., Ph.D., D.I.C.

The Bulletin brings together all the available information regarding grasshopper plagues in Australia, and presents this information in the form of a history of the different plagues, special attention being paid to the correct identification of the species involved and to seasonal and geographical distribution. It is shown that the most important plague grasshopper of the eastern States is *Chortoicetes terminifera* which has defined " outbreak centres " located for the most part in central New South Wales. The most important species in Western Australia, and to some extent in South Australia, is *Austroicetes cruciata.* The publication does not contain any discussion of control measures.

Bulletin No. 118.—" A Soil Survey of the Horticultural Soils in the Murrumbidgee Irrigation Areas of New South Wales," by J. K. Taylor, B.A., M.Sc., and P. D. Hooper.

This Bulletin contains descriptions of 24 soil series covering 33 soil types and 17 unnamed types. Soils containing 60 per cent. clay varied in field texture from clay loams to heavy clays indicating definite differences in the structure of the clay. The distribution of the soils throughout the area is dealt with by sections:—Ballingall, Griffith, Beelbangera, Yenda, Lakeview, Leeton, Wamoon, and Merungle Hill.

The important feature of soil structure is discussed in full to show its relationship to permeability to water. This leads directly to a statement of the problems of water-logging, irrigation methods, and development of salinity. It is shown that soil type exercises some control on the growth of plants, although the deterioration of soils under irrigation may alter the whole relationship.

Bulletin No. 119.—" The Wood Structure of Some Australian Cunoniaceae with Methods for their Identification " (Division of Forest Products Technical Paper No. 27), by H. E. Dadswell, M.Sc., and Audrey M. Eckersley, M.Sc.

For some time past, the Division of Forest Products has been examining different Australian timbers with a view to the development of keys for their identification. The present Bulletin discusses work that has been done in connexion with Australian Cunoniaceae. Previous reports in the same series were published as Bulletins 67, 78, 90, and 114.

Pamphlet No. 77.—" A Study of Persistency, Productivity, and Palatability in some Introduced Pasture Grasses," by A. McTaggart, Ph.D.

This publication discusses the characteristics of some 34 varieties or strains of grasses introduced into Australia from other countries. It follows several previous reports of a similar nature. The grasses discussed are classified according to the most productive species, the most persistent, the palatable, and the types found to be productive, persistent, and palatable at the one time.

Pamphlet No. 78.—" A Copper Deficiency in Plants at Robe, South Australia." 1. Preliminary Investigations on the Effect of Copper and other Elements on the Growth of Plants in a " Coasty " Calcareous Sand at Robe, South Australia, by D. S. Riceman, B.Ag.Sc., and C. M. Donald, B.Sc.Agr. 2. The Occurrence of " Reclamation Disease " in Cereals in South Australia, by C. S. Piper, M.Sc.

In the Council's Bulletin 113, it was tentatively suggested that the primary cause of coast disease in sheep—a malady which is of considerable hindrance to the sheep industry over some thousands of square miles along the southern coast of Australia—is a dual deficiency of cobalt and copper in the pastures of affected areas. It is shown in the present Pamphlet 78 that marked improvement in yield and health of cereals growing in at least some of these coast disease affected areas results from the application of small amounts of copper sulphate. Pasture grasses, however, though showing some response to the application of copper compounds, failed to make a normal development in the field with the particular dressing employed. Further work is in progress.

Pamphlet No. 79.—" A Report on the Conditions of Animal Production in Australia," by John Hammond, M.A., D.Sc., F.R.S.

Early in 1938, Dr. John Hammond visited New Zealand and Australia. In the latter country he was asked to examine and report on the present status of the methods of production in Australia in so far as beef cattle, dairy cattle, pigs, and lamb and mutton sheep are concerned. He was asked to report, in particular, on these matters in reference to breeding for production, nutrition, husbandry, and the type and quailty of the meat products being marketed. He was also

asked to compare the present Australian practices in these matters with those current elsewhere, and to indicate means of improvement in the former. All these matters are covered in his report.

Pamphlet No. 80.—"The Storage of Oranges with Special Reference to Locality, Maturity, Respiration, and Chemical Composition," by S. A. Trout, M.Sc., Ph.D., G. B. Tindale, B.Agr.Sc., and F. E. Huelin, B.Sc., Ph.D.

This Pamphlet gives the results of investigations carried out by the Council and the Victorian Department of Agriculture working in co-operation. The results included were all obtained prior to the year 1935, in which year the investigations on the handling and storage of citrus fruits from New South Wales, Victoria, and South Australia were placed under the direction of the Citrus Preservation Technical Committee comprising representatives of the Council and the respective Departments of Agrciulture.

Forthcoming Publications of the Council.

At the present time the following future publications of the Council are in the press:—

Bulletin No. .—"Some Effects of Green Manuring on Citrus Trees and on the Soil," by E. S. West, B.Sc., M.S., and A. Howard, M.Sc.

Bulletin No. .—"Observations on the Toxicity of Fluorine for Sheep," by A. W. Peirce, M.Sc.

Bulletin No. .—"A Soil Survey of the Merbein Irrigation District, Victoria," by F. Penman, M.Sc., J. K. Taylor, B.A., M.Sc., P. D. Hooper, and T. J. Marshall, M.Agr.Sc.

Bulletin No. .—"Radio Research Board—Report No. 14," by H. C. Webster, Ph.D., F.Inst.P., G. H. Munro, M.Sc., A.M.I.E.E., and A. J. Higgs, B.Sc.

Bulletin No. .—"The Establishment of Pastures on Deep Sands in the Upper South-east of South Australia." 1. The Scope and Origin of the Investigations, by H. C. Trumble, D.Sc., M.Agr.Sc. 2. The Influence of Cover Growths and Fertilizer Treatment on the Establishment of Selected Herbage Species, by C. M. Donald, B.Sc.Agr., and C. A. Neal Smith, B.Ag.Sc. With an Appendix on the Rôle of Seed Inoculation, by T. H. Strong, M.Sc.Agr.

Pamphlet No. 81.—"The Properties of Australian Timbers, Part 3, *Pinus radiata*."

Pamphlet No. 82.—"The Humidity of the Atmosphere and the Moisture Conditions within Mounts of *Eutermes exitiosus* Hill," by R. V. Fyfe, B.Sc.Agr., and F. J. Gay, B.Sc.

Pamphlet No. 83.—"Fleece Investigations," by F. G. Lennox, M.Sc., A.I.C.

Pamphlet No. .—"A Population Study of the Red-legged Earth Mite (*Halotydeus destructor*) in Western Australia with Notes on Associated Mites and Collembola," by K. R. Norris, M.Sc.

H. J. Green, Government Printer, Melbourne.

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